

original scientific article
received: 2005-04-13

UDC 594.3:591.9(262.3-18)

UNUSUAL SEA SLUG FROM CAPE MADONA (PIRAN, SLOVENIA) – THE FIRST RECORD OF *CUMANOTUS BEAUMONTI* (ELIOT, 1906) IN THE MEDITERRANEAN SEA

Tom TURK

University of Ljubljana, Biotechnical Faculty, Department of Biology, SI-1000 Ljubljana, Večna pot 111
E-mail: tom.turk@bf.uni-lj.si

ABSTRACT

Two specimens of an unusual nudibranch were found during the winter scuba dive off Cape Madona, Piran, northern Adriatic Sea. The specimens were identified as Cumanotus beaumonti (Eliot, 1906) (Nudibranchia, Aeolidioidea, Cumanotidae). To the best of our knowledge, it is the first record of this rare species in the Mediterranean Sea.

Key words: *Cumanotus beaumonti*, first record, Gulf of Trieste, Mediterranean Sea

NUDIBRANCO INUSUALE A PUNTA MADONNA (PIRANO, SLOVENIA) – PRIMA SEGNALAZIONE DI *CUMANOTUS BEAUMONTI* (ELIOT, 1906) IN MARE MEDITERRANEO

SINTESI

Due individui di un'insolita specie di nudibranco sono stati trovati durante un'immersione invernale al largo di Punta Madonna, Pirano, Adriatico settentrionale. Gli esemplari sono risultati appartenenti alla specie Cumanotus beaumonti (Eliot, 1906) (Nudibranchia, Aeolidioidea, Cumanotidae). Secondo le conoscenze dell'autore, si tratta della prima segnalazione di questa rara specie nel mare Mediterraneo.

Parole chiave: *Cumanotus beaumonti*, prima segnalazione, Golfo di Trieste, mare Mediterraneo

INTRODUCTION

Only few records of nudibranchs belonging to the genus *Cumanotus* are known so far. Three species are currently described: *Cumanotus cuenoti*, Pruvot-Fol, 1948 from the Atlantic coast of Southern France (Archachon basin) and *Cumanotus beaumonti* from only few localities in the Northern Atlantic along the western coasts of British Isles and Norway (Picton & Morrow, 1994). The third species, *Cumanotus fernaldi* Thompson & Brown, 1984, is known from the Northern Pacific along the coasts of US and Canada. The taxonomic status of the latter is not entirely clear and may actually be only a synonym for *C. beaumonti*. None of the described species had been previously recorded in the Mediterranean.

While *C. cuenoti* is a small species not exceeding the overall length of 1 cm, *C. beaumonti* can reach up to 3 cm in length. It is difficult to say whether the two species are distinct, as our knowledge of each is based on only very few specimens. Thompson & Brown (1984) note that *C. cuenoti* appears to be smaller, not exceeding 10 mm in length, lacking oral and propodial tentacles, and having fewer denticles on the radular teeth. The detailed description of *C. beaumonti* and its spawn based on 15 specimens collected along the coast of Northern Ireland is given in the paper of Picton (1991). According to his description, *C. beaumonti* has short but nevertheless clearly visible oral tentacles. Both species appeared to be specialists in terms of their diet. *C. cuenoti* feeds on hydroids *Tubularia* spp. and *Ectopleura dumortieri* (Tardy & Gantes, 1980), *C. beaumonti* on large athecate solitary hydroids of *Corymorpha nutans* (Picton & Morrow, 1994). *C. fernaldi* probably feeds on different *Tubularia* species. We lack any data about the life cycle and reproduction of these sea slugs.



Fig. 1/Sl. 1: *Cumanotus beaumonti* (Eliot, 1906). (Photo/Foto: B: Furlan)

MATERIAL AND METHODS

The nudibranchs were found during the routine dive in early April 2005 (2nd April). Although this is early springtime, the diving conditions were wintry. Scuba tanks filled with air and winter drysuits were used. The nudibranch specimens were photographed with Nikon F5, equipped with 105/2.8 AF Micro-Nikkor lens (Nikon Corp. INC., Japan) accommodated in a Seacam underwater housing (Seacam, Austria). A 200 W/s underwater strobe (Seaflash 200 TTL, Seacam Austria) was used to illuminate the subjects. The water temperature was 8 °C (recorded with diving thermometer), while the depth where the nudibranchs were found was 20 m (recorded with Aladin diving computer, Uwatech, Switzerland). Specimens were not collected or preserved; the identification was done solely on visual basis from the obtained pictures.

RESULTS

Two specimens identified as *Cumanotus beaumonti* were found on the muddy bottom at a depth of 20 m (Figs. 1, 2). They were of about equal size, measuring 3 cm in length. At first glance they seemed like small sea anemones embedded in the sand. They were slowly crawling on the bottom surface. In order to get a more contrast picture of the slugs, which actually crawled slowly along the bottom, one of them was picked up and taken to a rock nearby. In contrast to the earlier reports on this species as well as on *Cumanotus cuenoti* (Tardy & Gantes, 1980; Picton, 1991; Picton & Morrow, 1994), the nudibranch was not swimming when it was picked up and released, but rather sank slowly back to the sea bed. According to the visual appearance of the specimens from Piran and another existing picture from the British Isles (Picton & Morrow, 1994), we can give the following description of the animal: the body is broad and translucent with white and gold speckling covering the head, back and cerata. According to Picton & Morrow (1994), the long, slender cerata are arranged in 8 to 12 transverse ridges with 6 to 9 cerata in each ridge. The cerata are broader at the base and gradually tapering towards their ends. The three anterior ceratal ridges are situated in front of the very long, smooth rhinophores, which are clearly visible on the specimens' pictures from Piran. The digestive gland in the cerata ranges from brown to reddish pink. The ceratal wall is translucent clear with gold and white speckling and white tips. The head is broad with distinctive tentacular anterior foot corners. The oral tentacles are short, but distinct. The last two features are not clearly visible on the specimens from Piran, as the long anterior cerata obscure the view of the head, except on the picture of a floating specimen where a short foot corner or short oral tentacle is visible on the low left side of the animal.

DISCUSSION

The occurrence of *Cumanotus beaumonti* (Eliot, 1906) in the Northern Adriatic came as a big surprise, considering that members of the genus *Cumanotus* had been till then known only from the cold parts of the Atlantic and Pacific Oceans. Even there they are considered to be quite rare and can be only found during the short winter period. The exception was the population of *C. beaumonti* from the coast of Northern Ireland. These specimens were collected in June 1985 (Picton, 1991). Otherwise, *C. beaumonti* is currently known only from three localities along the west coast of Britain and one locality from Norway, where it is considered to be very rare. Our paper reports on the first record of this species in the Mediterranean Sea, suggesting that the species has a much wider geographic distribution than believed so far. The rare finds in the Northern Atlantic may suggest either that the geographic range cantered much further south or a very sporadic appearance of this species. The related, although smaller species *Cumanotus cuenoti* is found only in the Arcachon basin (Southern Atlantic coast of France), but even there it is considered quite rare and its brief appearance is limited to about one winter month, usually February (Poddubetskaia, *pers. comm.*). The same seems to hold true for the Pacific species *Cumanotus fernaldi*, which also appears only in the winter (Millen, *pers. comm.*).

In winter, the Gulf of Trieste, this northernmost part of the Adriatic Sea, is considered the coldest part of Mediterranean. In February or early March, the temperature of the sea water reaches its annual lows of about 8 °C. In exceptionally cold winters (which was the case of the winter 2004/2005) as well as frequent and strong bora winds blowing in this region, the water temperature may be even a few degrees lower and does not warm up substantially till mid April. These are conditions that meet the needs of boreal species to survive for a brief period of the year. However, the Gulf of Trieste becomes one of the warmest parts of the Mediterranean during the summer, when annual temperature peaks can easily exceed 25 °C. Since the Gulf of Trieste is very shallow (the maximum depth is only about 25 metres, disregarding a couple of deeper areas), the temperatures at the bottom differs from surface temperatures by only few degrees centigrade. Such conditions do not guarantee the survival of boreal species and cannot be compared with the temperature of deep oceanic waters of the Northern Atlantic or Pacific, where seasonal fluctuations of water temperature are much smaller. Therefore, the survival of a boreal species such as *C. beaumonti* in temperature extremes present during the year in the Gulf of Trieste is puzzling. Picton (1991) suggests that *C.*



Fig. 2/Sl. 2: *Cumanotus beaumonti* (Eliot, 1906). (Photo/Foto: B: Furlan)

beaumonti is able to bury into the soft bottom, and this might be the way to survive the warmer part of the year.

Another reason for the sudden appearance of *C. beaumonti* in the Northern Adriatic may be the availability of its preferred diet, which is supposed to be large athecate solitary hydroids of *Corymorpha nutans* (Picton & Morrow, 1994). These animals were present in large numbers during the past winter and early spring. However, the appearance of *C. nutans* is sporadic (*personal observations*). There are years, when not a single animal could be found. The abundance of preferred food for *C. beaumonti* might therefore be the reason for the existence of this species in our waters. Picton (1991) speculates that *C. beaumonti* is able to swim or drift in the ocean currents and follow its prey – the medusae of *C. nutans* – to new locations. We were not able to confirm the two specimens' swimming abilities during their observations in the Northern Adriatic.

Finally, we should also consider that *C. beaumonti* might not be so rare in our waters, but that the lack of more records is simply due to the fact that not many people are diving in harsh winter conditions, which are obviously favourable for *C. beaumonti*. It is also possible that due to its coloration and overall appearance the slug could be easily overlooked or simply mismatched for a small sea anemone.

ACKNOWLEDGEMENT

Credits to this contribution go to Borut Furlan, the underwater photographer who found the slugs and provided us with excellent pictures and important details. Thanks also to Bill Rudman from the Australian Museum, Sydney, for identifying the slug.

NENAVADNO ODKRITJE MORSKEGA POLŽA OB RTU MADONA PRI PIRANU –
PRVI PODATEK O VRSTI *CUMANOTUS BEAUMONTI* (ELIOT, 1906)
V SREDOZEMSKEM MORJU

Tom TURK

Univerza v Ljubljani, Biotehniška fakulteta, Oddelek za biologijo, SI-1000 Ljubljana, Večna pot 111
E-mail: tom.turk@bf.uni-lj.si

POVZETEK

Avtor poroča o odkritju dveh primerkov nenavadnega gološkrjarja med potopom ob Rtu Madona pri Piranu. Ugotovljeno je bilo, da gre za vrsto *Cumanotus beaumonti* (Eliot, 1906) (Nudibranchia, Aeolidioidea, Cumanotidae) in – glede na obstoječe podatke – tudi za prvo odkritje te redke vrste v Sredozemskem morju.

Ključne besede: *Cumanotus beaumonti*, prvi podatek, Tržaški zaliv, Sredozemsko morje

REFERENCES

- Picton, B. E. (1991):** *Cumanotus beaumonti* (Eliot, 1906), a nudibranch adapted for life in a shallow sandy habitat? *Malacologia*, 32, 219–222.
- Picton, B. E. & C. C. Morrow (1994):** A field guide to the nudibranchs of the British Isles. Immel Publishing Ltd., London, 143 pp.
- Tardy, J. & H. Gantes (1980):** Un Mollusque Nudibranche peu connu: *Cumanotus cuenoti* A. Pruvot-Fol, (1948); redescription, biologie. *Bull. Soc. Zool. Fr.*, 105, 199–207.
- Thompson, T. E. & G. H. Brown (1984):** Biology of Opisthobranch Molluscs. Vol. 2. Ray Society, London, 229 pp.

original scientific article
received: 2005-04-14

UDC 639.32:504.064(262.3-18)

EFFECTS OF AN INTENSIVE CAGE FARM ON THE MACROBENTHOS IN THE GULF OF TRIESTE (NORTHERN ADRIATIC SEA)

Ida Floriana ALEFFI

Laboratorio di Biologia Marina, I-34010 Trieste, Via A. Piccard 54, Italy
E-mail: aleffi@univ.trieste.it

Giulio BRIZZI

Chlamys srl, I-70121 Bari, Via Argiro 90, Italy

Romina ZAMBONI

Università degli Studi di Trieste, Dipartimento di Biologia, I-34127 Trieste, Via Weiss 2, Italy

ABSTRACT

*Macrobenthos changes beneath a cage farm were investigated during October 2000 in the Gulf of Trieste (northern Adriatic Sea). The floating cage farm became operational in 1990, with an annual gross production of sea bream and sea bass of around 300 ton yr⁻¹. Eight stations were sampled: four beneath the cages, three at about 100 m from the cages and one at 250 m. The number of species ranged from a minimum of 21 under the cages to a maximum of 49 in the outside zone, while abundance was higher under the cages (1890 ind. m⁻²) than outside (933 ind. m⁻²). The dominant species were the opportunistic polychaetes *Neanthes caudata* and the mollusc *Mytilus galloprovincialis*. Despite the huge gross cage production, the impacts were not as severe as those described under similar organic enrichment conditions elsewhere; they did, however, show a decrease in species richness, a replacement of the typical muddy community with more tolerant and opportunistic species, and an increase of abundance values.*

Key words: mariculture, sea bream, sea bass, impact, Gulf of Trieste

EFFETTI DELLA PESCOLTURA INTENSIVA IN GABBIE SUL MACROBENTHOS DEL GOLFO DI TRIESTE (NORD ADRIATICO)

SINTESI

*Nel Golfo di Trieste, ad ottobre 2000, sono state analizzate le modificazioni del macrobenthos dovute alla presenza di un impianto di piscicoltura in gabbie. L'impianto ha iniziato ad essere operativo nel 1990 ed ha una produzione lorda annuale di circa 300 tonnellate di orate e branzini. Sono state campionate otto stazioni: quattro al di sotto delle gabbie, tre a circa 100 m ed una a 250 m. Il numero di specie varia da un minimo di 21 sotto alle gabbie e 49 nella zona esterna, mentre i valori di abbondanza sono più elevati sotto alle gabbie (1890 ind. m⁻²) rispetto alle stazioni esterne (933 ind. m⁻²). Le specie dominanti sono il polichete opportunistica *Neanthes caudata* ed il mollusco *Mytilus galloprovincialis*. Malgrado l'elevata produzione dell'impianto, la comunità bentonica non sembra aver subito il forte impatto descritto in simili condizioni di arricchimento organico, si nota, però, una riduzione nel numero di specie, una sostituzione delle specie caratteristiche dei fondi fangosi con specie più tolleranti ed opportuniste, ed un aumento dei valori di abbondanza.*

Parole chiave: piscicoltura, orate, branzini, impatto, Golfo di Trieste

INTRODUCTION

Marine aquaculture has shown a huge increase in production in several Mediterranean countries over the past few decades. Mariculture expansion, mainly based on floating cage farms in sheltered areas, has led to concerns regarding the effects on the environment. Fish farming produces organic waste primarily composed of uneaten feed and fecal material (Iwama, 1991), which partially settles on the seabed, leading to changes in sediment quality (Karakassis *et al.*, 1998; McGhie *et al.*, 2000; Kovač *et al.*, 2001) and benthic communities (Ritz *et al.*, 1989; Weston, 1990). The macrofauna is a good indicator for monitoring the impact of aquaculture on the marine environment considering that the community structure can be related to the stage of degradation. Changes in benthic communities related to organic enrichment were exhaustively described by Pearson & Rosenberg (1978).

The macrobenthos beneath a cage farm and in the surrounding area was investigated in the Gulf of Trieste (northern Adriatic Sea) in order to evaluate the degree of disturbance directly related to the cages. The floating cage farm, covering some 25,000 m² and located close to about thirty years old mussel farms, began to operate in 1990. The annual gross production of sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*) was around 300 ton yr⁻¹ in the last five years. The farm oper-

ates from April to November, for during this period the water temperature in the Gulf of Trieste is above 14 °C (Celio *et al.*, *in press*) and the fish are fed. In contrast, during the winter, when temperature falls below 10 °C, fish are fed at a very low percentage of body weight, with a strong reduction in the amount of organic matter reaching the bottom.

MATERIAL AND METHODS

The study area is located in the northernmost part of the Gulf of Trieste, Italy. The shallow bay (maximum depth 25 m) is characterized by high hydrological variability due to a wide thermal differences between winter and summer, to major freshwater inputs, and to the action of tide and winds. Annual variations in temperature and salinity cover the range 6.5–28 °C and 22–38, respectively (Bussani *et al.*, 2003). The tidal current amplitude is on the order of 10 cm s⁻¹ (Malačič & Viezzoli, 1998), while the drift current can reach 50 cm s⁻¹ with ENE winds (Mosetti & Purga, 1990).

In the area where the cages are situated, the complexity of the hydrological features of the Gulf is increased by the shallow depth (10 m), by the influence of the Isonzo and Timavo Rivers, and by the artificial confinement of the farm caused by the screen effect of the surrounding mussel long-lines.

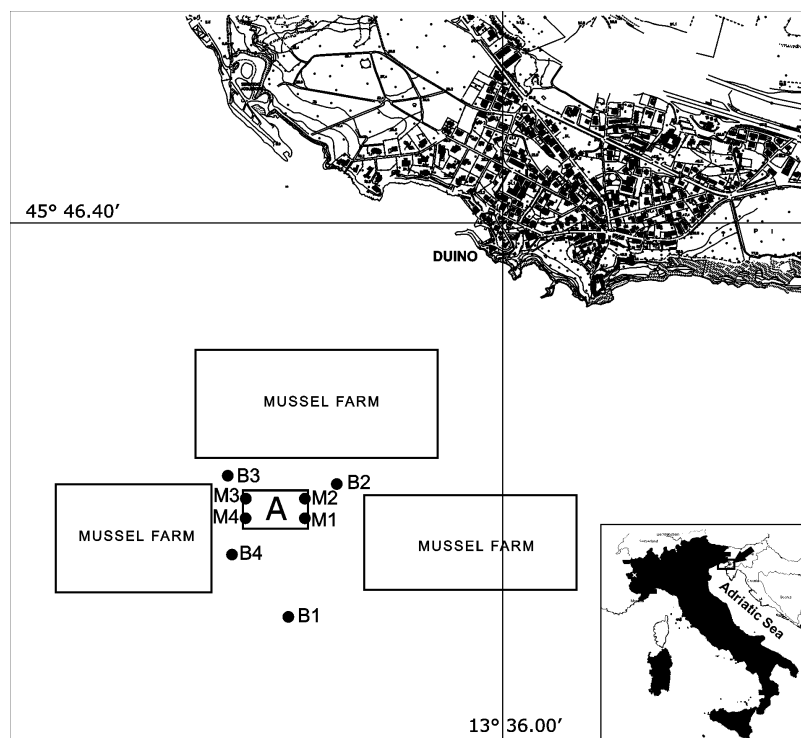


Fig. 1: Map showing location of sampling stations; (A) denotes fish farm area.

Sl. 1: Zemljevid z lokacijami vzorčnih mest; (A) ponazarja območje gojenja rib v kletkah.

Direct observations by scuba-divers were carried out in order to identify the potential presence and visible spatial extent of the impact (e.g. blackened sediment) and the presence of bacterial mats. In October 2000, eight stations were sampled: four along the edge of the cages (M1, M2, M3, M4), three (B2, B3, B4) at 100 m from the cages and from the mussel farm, and one – considered as a control station (B1) – at about 250 m from both (Fig. 1). The stations are situated at an average depth of 10 m on muddy sediment. At each station, four replicates were collected with a 0.1 m² van Veen grab, sieved through a 1 mm mesh and preserved in 4% buffered formalin.

The structure of benthic community was analysed as species composition, abundance, Shannon-Wiener diversity index (H) on log_e basis (Shannon & Weaver, 1949), evenness (J) (Pielou, 1966), and k-dominance curves. Non-metric multi-dimensional scaling (MDS) ordination was performed according to the Bray-Curtis similarity index on square-root transformed abundance data.

RESULTS

Diver's observations beneath the cages revealed no black mud or bacterial mats at the sediment surface. Mussel clumps and debris (net parts and ropes) coming from cages and mooring system were evident on the bottom.

A total of 110 species and 8,046 individuals were collected at the eight stations. The number of species ranged from 21 at station M3 to 49 at B3, while total abundance ranged from 383 ind. m⁻² at B1 to 1890 ind. m⁻² at M1 (Tab. 1). The highest diversity and evenness values were found at station B3 (3.24) and at station B1 (0.86), the lowest at station M3 for both indices ($H' = 1.49$ and $J = 0.49$). In all samples, the dominant taxon, both for species richness and abundance, were polychaetes, as already shown for the muddy sediments of the Gulf of Trieste (Brizzi *et al.*, 1995; Aleffi *et al.*, 1996).

The dominant species beneath the cages was *Neanthes caudata*, whose density was 650 ind. m⁻² at M1 and 630 at M3, while its density reached 188 and 128 ind. m⁻² at stations M2 and M4, respectively (Fig. 2). *Mytilus galloprovincialis* and Decapoda were also more abundant under the cages.

In order to test community stress at any station, the k-dominance curves were used, in which species are ranked in order of abundance on the x-axis with percentage dominance on the y-axis (cumulative scale) (Fig. 3). The curves were clearly more elevated at stations M1–M4, indicating an increase in species dominance beneath the cages. The elevation of the curve for M3 resulted from the high abundance of the polychaete *N. caudata* (630 ind. m⁻²). Station B4 represented an intermediate state, while B1, B2 and B3 had lower partially overlapping curves.

Figure 4 shows the MDS configuration plot, with superimposed cluster groupings at a similarity level of 40%. There was a clear separation of B1 and B3 (group 1) from the other stations (group 2). In group 2, station M3 was separated from the others, according to the representation of the relationship among samples given by the MDS plot.

Tab. 1: Number of species (S), abundance (N), Shannon-Wiener diversity index (H'), and evenness (J) at each station.

Tab. 1: Število vrst (S), številčnost (N), Shannon-Wienerjev diverzitetni indeks (H') in indeks enakomernosti porazdelitve (J) na vsakem vzorčnem mestu.

	Stations under the cages				Stations outside the cages			
	M1	M2	M3	M4	B1	B2	B3	B4
S	44	44	21	36	37	47	49	48
N (ind. m ⁻²)	1890	1078	1058	1285	383	643	803	933
H'	2.38	2.31	1.49	2.09	3.1	3.11	3.24	2.65
J	0.63	0.61	0.49	0.58	0.86	0.81	0.83	0.68

DISCUSSION

The number of species at station M3 (beneath the cages) was considerably lower compared to the values found at the other stations, which showed richness close to other areas of the Gulf of Trieste (Solis-Weiss *et al.*, 2001). The total abundance recovered in samples collected on muddy bottoms in the Gulf is on average around 1000 ind. m⁻² (Aleffi *et al.*, 1995). In the study area, abundance was comparable to the muddy sediments of the Gulf, with an increase beneath the cages (Tab. 1).

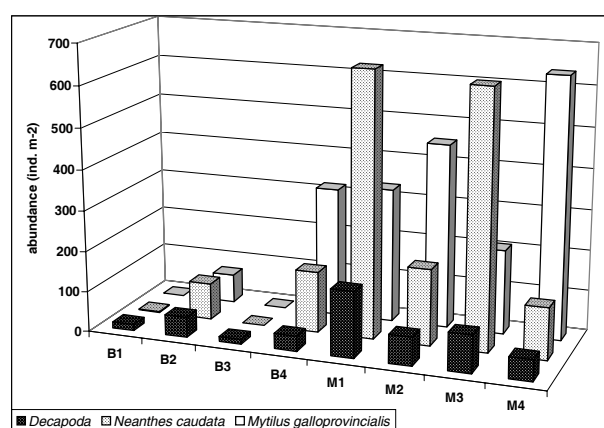


Fig. 2: Abundance of the dominant species and taxa at sampling stations.

Sl. 2: Številčnost prevladujočih vrst in taksonov na vzorčnih mestih.

The dominant species beneath the cages was *N. caudata*, an opportunistic species (Bellan, 1967). This may be related to the appearance of the "opportunistic peak" reported in Pearson & Rosenberg (1978) under the effect of organic load. K-dominance curves provided evidence of disturbance at the stations under the cages, especially at M3. Station B4 showed a high dominance of *M. galloprovincialis* and *N. caudata*, being at an intermediate community stress level: together, these two species made up 50% of the total abundance at the station.

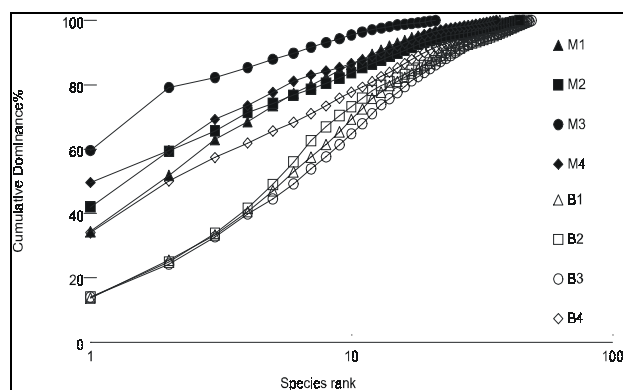


Fig. 3: K-dominance curves for abundance at sampling stations under (closed symbols) and outside (open symbols) the cages.

Sl. 3: Krivulje dominanc K za številčnost na vzorčnih mestih pod kletkami (zaprti simboli) in zunaj njih (odprti simboli).

Analysing the species composition of the two main groups derived from the dendrogram, group 1 (stations B1 and B3) was distinguished by the presence of the polychaetes *Maldane glebifex* and *Laonice cirrata*, characteristic of the biocoenoses of the terrigenous mud (VTC) as described by Pérès (1967), and by *Terbellides stroemi* and *Melinna palmata*, commonly found on muddy bottoms. Among molluscs, the dominant in group 1 was *Dentalium inaequicostatum*. The second group of stations was pooled based on the presence and abundance of the molluscs *M. galloprovincialis* and *Nucula nucleus*, the polychaetes *N. caudata* and *Marphysa sanguinea*, and the crustaceans *Processa* spp., *Pisidia longimana* and *Brachynotus sexdentatus*. Among these species, *M. galloprovincialis* had fallen directly from the upper floating cages and ropes, while Decapoda were associated with secondary hard substrata formed by ropes, nets and mussel shells: they were also the dominant epibenthic invertebrates beneath the mussel farm in the Ria de Arousa (Freire *et al.*, 1996). Some species commonly indicating organic enrichment (Bellan, 1967; Pearson & Rosenberg, 1978), such as *N. caudata* (ranging from 90 ind. m⁻² to 650 ind. m⁻²) and few specimens of the polychaetes *Malacoceros fuliginosus* and *Capi-*

tella capitata, were present. *C. capitata* is rarely found in the Gulf of Trieste, even in heavily polluted areas (Bellan & Pérès, 1972; Orel *et al.*, 1987), and has never been recorded at high density. In contrast, it was frequently found under fish cages in many other geographical areas (Pocklington *et al.*, 1994; Karakassis *et al.*, 1999). Note also the absence of *M. glebifex*, which is widely distributed in the muddy bottoms of the Gulf (Solis-Weiss *et al.*, 2001); this is probably related to anthropogenic modifications that alter the natural density of the sediment, as noted in previous studies under the mussel long-lines of the Gulf of Trieste (Brizzi *et al.*, 1995).

The MDS plot outlined a gradient of increasing disturbance moving from station B1 - B3 to M3. Stations B2 and B4, although positioned outside the cages, occupied an intermediate position, and were close to M2 and M4 owing to the abundance of *N. caudata* and *M. galloprovincialis*. The farm's disturbance and impact on the benthic community seemed to be more intense in a restricted area comprising the cages' perimeter and station B4. The reference station (B1) was unaffected in consideration of the presence of species characteristic of the muddy bottom of the Gulf and the lack of indicator species of organic enrichment. The outer stations were slightly disturbed at the most, possibly a combined effect due to the proximity of the cages and the mussel farms, even if, generally, the impact of shellfish lines is not as deleterious as that of the fish farms (Pocklington *et al.*, 1994), as the latter involves a net addition of organic matter in the form of fish feed to the environment. The effects at stations B2 and B4 were thus most probably related to the fish farm.

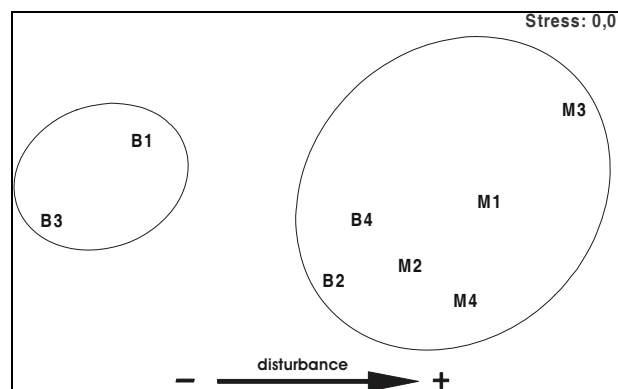


Fig. 4: Multidimensional scaling (MDS) for each station with cluster superimposed.

Sl. 4: Večdimenzionalno skaliranje (MDS) za vsako vzorčno mesto z označenimi klasterji.

Other authors have observed bottom effects limited to the immediate vicinity of fish cages, generally depending on the water circulation pattern (Weston, 1990; Johnsen *et al.*, 1993). The huge production level of the

farm did not lead to a disturbance comparable to the impact described elsewhere for similar production levels (Angel *et al.*, 1995), even if, generally, fish farming above fine sediments, such as present in this study, has the potential for severe environmental impact (Lauren-Maatta *et al.*, 1991). The relatively low impact level may be due to the short feeding period of the fish during the year (8 months) and to the strong dilution of feed and fecal wastes by the intense tidal and inertial streams. The average water current velocity of about 8 cm s^{-1} in the coastal area (Martinčić *et al.*, 1998) may have been enough to reduce the effects of organic enrichment, limiting biodeposition on the bottom. An average current of about 6 cm s^{-1} , for example, was sufficient to disperse solid wastes of a cage farm at Gran Canaria Island, as noted by Molina Domínguez *et al.* (2001).

The macrobenthic communities in the Gulf of Trieste receive high sedimentary loads due to the proximity of the Isonzo and Timavo river mouths and to an organic load from the heavily populated coast. The Gulf is characterized by high environmental instability, both natural

(*i.e.* hypoxic and anoxic events, aperiodic mucilage production) and anthropogenic (*i.e.* urban development, sewage ducts discharges, intensive sea traffic and trawl fisheries, tourist activities) that has led to selective pressure on the community towards a more resilient state (Solis-Weiss *et al.*, 2001). So, in consideration of the overall situation, fish cages represent only one, and localized, problem for the Gulf.

CONCLUSIONS

Our study revealed that although the gross cage production is huge, the bottom was not azoic as described under similar organic enrichment conditions elsewhere. Nevertheless, we observed clear modification of the benthic community that can be summarized by: a) a weak decrease in species richness, except for in a restricted area in which the decrease was stronger, b) a substitution of the typical muddy community with certain more tolerant and opportunistic species, c) a considerable increase in abundance values.

UČINKI INTENZIVNEGA GOJENJA RIB V KLETKAH NA MAKROBENTOS V TRŽAŠKEM ZALIVU (SEVERNI JADRAN)

Ida Floriana ALEFFI

Laboratorio di Biologia Marina, I-34010 Trieste, Via A. Piccard 54, Italy

E-mail: aleffi@univ.trieste.it

Giulio BRIZZI

Chlamys srl, I-70121 Bari, Via Argiro 90, Italy

Romina ZAMBONI

Università degli Studi di Trieste, Dipartimento di Biologia, I-34127 Trieste, Via Weiss 2, Italy

POVZETEK

V oktobru 2000 so avtorji prispevka preučevali spremembe v makrobentosu pod kletkami za gojenje rib v Tržaškem zalivu (severni Jadran). V plavajočih kletkah se je gojenje rib začelo leta 1990, z letno bruto pridelavo orad in brancinov v višini približno 300 ton. Avtorji so vzorce jemali na osmih postajah: na štirih pod kletkami, na treh kakih 100 m od njih, medtem ko je bila zadnja od kletk oddaljena 250 m. Število vrst se je sukalo od najmanj 21 pod kletkami do največ 49 v zunanjem pasu, medtem ko je bila številčnost večja pod kletkami (1890 osebkov/m^2) kot zunaj (933 osebkov/m^2). Prevladujoče vrste so bile oportunistični mnogoščetinci *Neanthes caudata* in mehkužci *Mytilus galloprovincialis*. Kljub izjemno visokemu bruto prirastku rib v kletkah pa vplivi niso bili tako veliki kot tisti, opisani v podobnih razmerah organskega bogatenja drugod. Zato pa so zagotovo povzročili, da se je zmanjšalo bogastvo vrst, da so značilne skupnosti na blatnem dnu nadomestile bolj tolerantne in oportunistične vrste in da se je povečala številčnost vrst.

Ključne besede: marikultura, orada, brancin, vplivi, Tržaški zaliv

REFERENCES

Aleffi, F., G. Della Seta, F. Goriup, P. Landri & G. Orel (1995): Fattori climatici ed edafici e popolamenti bentonici dell'Adriatico settentrionale e del Golfo di Trieste.

Atti del Convegno "Evoluzione dello stato trofico in Adriatico: analisi degli interventi attuati e future linee di intervento". 28-29 settembre 1995, Marina di Ravenna, Italia, p. 81-99.

- Aleffi, F., F. Goriup, G. Orel & V. Zuccarello (1996):** Analysis of macrobenthic community structure in three areas of the Gulf of Trieste. *Annales Ser. Hist. Nat.*, 9, 39–44.
- Angel, D., P. Krost & B. Silvert (1995):** Benthic effects of fish cage farming in the Gulf of Aqaba, Red Sea. Modeling environmental interactions of mariculture. 8–9 Sept 1995, Dartmouth, Canada. ICES C.M. 1995/F:6.
- Bellan, G. (1967):** Pollution et peuplements benthiques sur substrat meuble dans la région de Marseille. 1^{re} partie. Le secteur de Cortiou. *Rev. Int. Oceanogr. Med.*, 8, 51–95.
- Bellan, G. & J. M. Pérès (1972):** La Pollution dans le Bassin Méditerranéen (Quelques Aspects en Méditerranée Nord-occidentale et en Haute Adriatique: Leurs Enseignements). In: Ruivo, M. (ed.): Marine pollution and sea life. FAO, Fishing News L.T.D., Surrey, p. 32–35.
- Brizzi, G., F. Aleffi, F. Goriup, P. Landri & G. Orel (1995):** Modification in benthos under mussel cultures in the Gulf of Trieste (North Adriatic Sea). *Annales Ser. Hist. Nat.*, 7, 17–26.
- Bussani, A., M. Celio & C. Comici (2003):** Climatological analysis (1991–2002) of the thermohaline characteristics in the Marine Reserve of Miramare (Gulf of Trieste). *Boll. Geof. Teor. Appl.*, 44(1), 11–17.
- Celio, M., V. Malačič, A. Bussani, B. Čermelj, C. Comici & B. Petelin:** The coastal scale observing system component of Adricosm: the Gulf of Trieste network. *Acta Adriat.* (in press)
- Freire, J. (1996):** Feeding ecology of *Liocarcinus depurator* (Decapoda: Portunidae) in the Ria de Arouse (Galicia, north-west Spain): effects of habitat, season and life history. *Mar. Biol.*, 126, 297–311.
- Iwama, G. I. (1991):** Interactions between aquaculture and the environment. *Crit. Rev. Environ. Control*, 21, 177–216.
- Johnsen, R. I., O. Grahl-Nielsen & O. Lunestad (1993):** Environmental distribution of organic waste from a marine fish farm. *Aquaculture*, 118, 229–244.
- Karakassis, I., M. Tsapakis & E. Hatziyanni (1998):** Seasonal variability in sediment profiles beneath fish farm cages in the Mediterranean. *Mar. Ecol. Prog. Ser.*, 62, 243–252.
- Karakassis, I., E. Hatziyanni, M. Tsapakis & W. Plaiti (1999):** Benthic recovery following cessation of fish farming: a series of successes and catastrophes. *Mar. Ecol. Prog. Ser.*, 184, 205–218.
- Kovač, N., B. Vrišer & B. Čermelj (2001):** Impacts of net cage farm on sedimentary biogeochemical and meiofaunal properties of the Gulf of Trieste. *Annales Ser. Hist. Nat.*, 11(1), 65–74.
- Laurén-Maatta, C., M. Granlid, H. Henriksson & V. Koivisto (1991):** Effects of fish farming on the macrobenthos of different bottom types. In: Makinen, T. (ed.): Marine aquaculture and Environment. Nordic Council of Ministers, Copenhagen, 22, p. 57–83.
- Malačič, V. & D. Viezzoli (1998):** Tidal dynamics in the Gulf of Trieste – Northern Adriatic. *Rapp. Comm. int. Mer Médit.*, 35, 172–173.
- Martinčić, B., C. Salvi & F. Tamberlich (1998):** Modello di carrying capacity applicato alle mitilcolture in sospensione nel Golfo di Trieste. *Hydrores*, 16, 7–23.
- McGhie, T. K., C. M. Crawford, I. M. Mitchell & D. O’Brain (2000):** The degradation of fish-cage waste in sediments during fallowing. *Aquaculture*, 187, 351–366.
- Molina Domínguez, L., G. López Calero, J. M. Vergara Martín & L. Robaina (2001):** A comparative study of sediments under a marine cage farm at Gran Canaria Island (Spain). *Aquaculture*, 192, 225–231.
- Mosetti, F. & N. Purga (1990):** Courant cotier de différente origine dans un petit golfe (Golfe de Trieste). *Boll. Oceanol. Teor. Appl.*, 8, 51–62.
- Orel, G., R. Marocco, E. Vio, D. Del Piero & G. Della Seta (1987):** Sedimenti e biocenosi bentoniche tra la foce del Po ed il Golfo di Trieste (Alto Adriatico). *Bull. Ecol.*, 18, 229–241.
- Pearson, T. H. & R. Rosenberg (1978):** Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanogr. Mar. Biol. Ann. Rev.*, 16, 229–311.
- Pérès, J. M. (1967):** The mediterranean benthos. *Oceanogr. Mar. Biol. Ann. Rev.*, 5, 449–533.
- Pielou, E. C. (1966):** The measurement of diversity in different type of biological collections. *J. Theor. Biol.*, 13, 131–144.
- Pocklington, P., D. B. Scott & C. T. Schafer (1994):** Polychaete response to different aquaculture activities. In: Dauvin, J., L. Laubier & D. J. Reish (eds.): Actes de la 4^{ème} Conf. intern. des Polychètes. *Mém. Mus. natn. Hist. nat.*, 162, 511–520.
- Ritz, D. A., M. E. Lewis & M. A. Shen (1989):** Response to organic enrichment of infaunal macrobenthic communities under salmonid seacages. *Mar. Biol.*, 103(2), 211–214.
- Shannon, C. E. & W. Weaver (1949):** Mathematical theory of communication. University of Illinois Press, Urbana, 117 pp.
- Solis-Weiss, V., P. Rossin, F. Aleffi, N. Bettoso, G. Orel & B. Vrišer (2001):** Gulf of Trieste: Sensitivity Areas Using Benthos and GIS Techniques. In: Ozhan, E. (ed.): Proc. Fifth International Conference on the Mediterranean Coastal Environment MEDCOAST 01. 23–27 October 2001, Hammamet, Tunisia. MEDCOAST, Middle East Technical University, Ankara, Turkey, vol. 1–3, p. 1567–1578.
- Weston, D. P. (1990):** Quantitative examination of macrobenthic community changes along an organic enrichment gradient. *Mar. Ecol. Prog. Ser.*, 61, 233–244.

original scientific article
received: 2005-09-12

UDC 574.5:593(262.3-18)

GELATINOUS ZOOPLANKTON ASSEMBLAGES IN TEMPERATE COASTAL WATERS – SEASONAL VARIATIONS (GULF OF TRIESTE, ADRIATIC SEA)

Čarna MILOŠ

SI-6281 Škofije, Spodnje Škofije 140

Alenka MALEJ

Marine Biology Station, National Institute of Biology, SI-6330 Piran, Fornače 41

E-mail: malej@mbss.org

ABSTRACT

Gelatinous plankton composition, abundance, biomass and their seasonality was studied in the Gulf of Trieste (Adriatic Sea) over a yearly cycle. The most diverse gelatinous groups were Hydromedusae with 14 species, followed by Siphonophora (six species), Appendicularia (five species), Chaetognatha (two species), and Thaliacea (one species). In addition, the alien species Muggiaea atlantica, introduced into the Adriatic Sea in the early 90s, was for the first time recorded in the Gulf of Trieste. The carbon and nitrogen contents of gelatinous taxa varied from 7.4 to 34.4% and from 1.4 to 7.9% of dry weight, respectively. On a yearly basis, gelatinous plankton contributed less than 8% to total zooplankton dry weight with the highest contribution in late autumn. Cluster analysis (Bray-Curtis index) enabled us to distinguish three main gelatinous assemblages over an annual cycle.

Key words: gelatinous zooplankton, seasonal dynamics, coastal waters, Adriatic Sea

COMUNITÀ GELATINOSE ZOOPLANCTONICHE IN ACQUE TEMPERATE COSTIERE – VARIAZIONI STAGIONALI (GOLFO DI TRIESTE, MARE ADRIATICO)

SINTESI

La composizione, l'abbondanza, la biomassa e la stagionalità del plancton gelatinoso sono state studiate nel Golfo di Trieste (mare Adriatico) nell'arco di un ciclo annuale. Il gruppo gelatinoso più vario, che comprende 14 specie di idromeduse, è seguito da sifonofori (6 specie), appendicularie (5 specie), chetognati (2 specie) e taliacei (1 specie). Nell'articolo viene segnalata per la prima volta la presenza nel Golfo di Trieste della specie aliena Muggiaea atlantica, introdotta in Adriatico negli anni novanta. I taxa gelatinosi hanno presentato variazioni nel contenuto di carbonio (da 7.4 a 34.4%) e azoto (da 1.4 a 7.9%) di peso secco. Su base annuale il plancton gelatinoso ha contribuito con meno dell'otto per cento al peso secco totale dello zooplancton, con un picco massimo nel tardo autunno. La Cluster analysis (indice di Bray-Curtis) ha permesso di distinguere tre principali comunità gelatinose nell'arco di un ciclo annuale. Diverse idromeduse, sifonofori moderatamente abbondanti e poche appendicularie hanno caratterizzato il periodo freddo pre-primaverile. Tunicati pelagici abbondanti (Thaliacea e Appendicularia), due specie di sifonofori e poche idromeduse hanno dominato il gruppo corrispondente ai mesi caldi. Una comunità planctonica con un'alta diversità e una moderata abbondanza ha invece rappresentato il terzo gruppo (novembre – gennaio).

Parole chiave: zooplancton gelatinoso, dinamica stagionale, acque costiere, mare Adriatico

INTRODUCTION

Gelatinous zooplankton forms a diverse pelagic group of animals belonging to different phyla (Cnidaria, Ctenophora, Mollusca, Chordata) with an important role in marine trophic webs that has been fully recognised only recently owing to their delicate bodies and the consequent difficulty of sampling, determination and laboratory experimentation. Despite their taxonomic diversity, these organisms share some common characteristics (Acuña, 2001) that define their life strategy: soft and transparent bodies without hard skeleton or thick muscles, high water content as a percentage of body mass, a relatively low carbon to dry mass ratio, and a rather large surface area relative to organic content (Larson, 1986). They are, with few exceptions, weak swimmers. These characteristics allow them a low maintenance metabolism and survival in a food diluted environment, but a rapid increase in size/numbers when food is plentiful. With few exceptions, gelatinous zooplankton show typical seasonality: they appear in masses in a given season while during the rest of the year they are rare or absent.

In spite of similarities among different gelatinous zooplankton, the trophic position of particular taxa are different and vary from grazers on picoplankton and nanoplankton (Thaliacea) to microzooplankton and larger mesozooplankton-feeders either through ambush (many Cnidaria, some Ctenophora) or as active predators (some Cnidaria and Ctenophora, pteropods, Chaetognatha). Due to a high growth rate and rapid generation time, gelatinous zooplankton may exert a significant grazing/predatory impact, seasonally outcompeting other planktonic grazers or predators. Results from several studies indicate that gelatinous organisms have important direct and indirect structuring impacts on the pelagic biodiversity (Batičić *et al.*, 2004) and on the pelagic food web including the microbial part (Riemann *et al.*, 2005; Malej *et al.*, *submit.*). However, most of these observations are based on larger gelatinous organisms, such as Scyphomedusae and Ctenophora. Gelatinous organisms have few predators and are frequently considered as a "sink" within the pelagic food chain (CIESM, 2001), although data have accumulated recently on the utilization of gelatinous plankton as prey as well (Mianzan *et al.*, 2001; Arai, 2005).

In coastal waters, the seasonality of gelatinous organisms has been related to changes in the physical characteristics and related trophic state of the pelagic environment (CIESM, 2001), *i.e.* the development of phytoplankton blooms which are replaced with oligotrophic conditions when nutrients are exhausted. The annual cycle of primary producers and their community structure in near-shore waters are generally controlled by nutrient inputs from freshwater inflow in conjunction with other environmental variables, such as temperature,

water column stratification, light availability and circulation (Valiela, 1995; Harding *et al.*, 1999; Roman *et al.*, 2005). In temperate waters, high biomass-high production periods are typically late winter-early spring and late summer-autumn, when phytoplankton is dominated by chain-forming diatoms. A mixture of nano-flagellates and small diatoms with lower biomass is characteristic of the transient period from spring to summer. The thermally stratified summer water column is characterized by high production-low autotrophic biomass and the prevalence of nano- and pico-sized phytoplankton. The described seasonality is also typical of the Gulf of Trieste, the northernmost part of the Adriatic Sea (Fonda Umani *et al.*, 1995; Malej *et al.*, 1995; Mozetič *et al.*, 1998). Trophic regime shifts, which are associated with seasonal variations, are expected to be reflected in changes in gelatinous zooplankton assemblages (Mills, 1995). In this study, we explored the community structure, and the abundance and biomass of planktonic gelatinous assemblages in relation to variable environmental and trophic conditions in different seasons.

MATERIAL AND METHODS

A survey of environmental characteristics and plankton was carried out in the eastern part of the Gulf of Trieste at locations deeper than 20 m as part of the long-term monitoring programme (Mozetič & Lipej, 2002). The vertical structure of temperature, salinity and fluorescence was assessed using CTD fine-scale probe (University of Western Australia and a Sea-Tech inc. fluorometer).

Zooplankton samples were collected monthly by bottom to surface vertical tows using WP-2 net (net diameter 56 cm, 200 µm mesh) during 2001. Half of the zooplankton samples were used for dry weight (60 °C) and ash-free dry weight (500 °C) determination following standard procedures (Postel *et al.*, 2000). From the other half of the samples, all gelatinous organisms were separated and identified, if possible, to the species level. All specimens were counted and the counts standardized to the number per m³. To obtain an objective description of the seasonal differences / similarities in gelatinous plankton assemblages, descriptive statistics was used. The Bray-Curtis similarity coefficient of (Field *et al.*, 1983) and the linkage rule of the un-weighted pair group method using arithmetic averages (Sneath & Sokal, 1973) were applied. These data were then used to plot classification diagrams of percentage similarity.

For analyses of carbon and nitrogen content, gelatinous organisms were pooled into five main groups: Hydromedusae, Siphonophora, Chaetognatha, Appendicularia and Thaliacea. Pooled samples were dried and carbon and nitrogen were determined using Carlo Erba elemental analyser (Pella & Colombo, 1978); the results were expressed as % of dry mass.

RESULTS

Physical environment

The water column was rather homogeneous in the winter months with temperatures ranging from 10.35 to 11.29 °C and salinities from 37.23 to 37.9 psu. In the top 2–5 m we recorded lower salinity values in March and July–August. In May, the surface layer warmed up to 18.20 °C, while the layer deeper than 15 m remained

colder (< 15 °C). The water column was well stratified from June to September with surface and bottom temperatures ranging between 23.0 and 25.92 °C and 17.65 and 20.49 °C, respectively. The thermocline and halocline were located at 15–18 m depth, creating a somewhat steep pycnocline. The water column became more vertically homogeneous from October on with temperatures around 20 °C in October, 16 °C in November and 12 °C in December (Fig. 1).

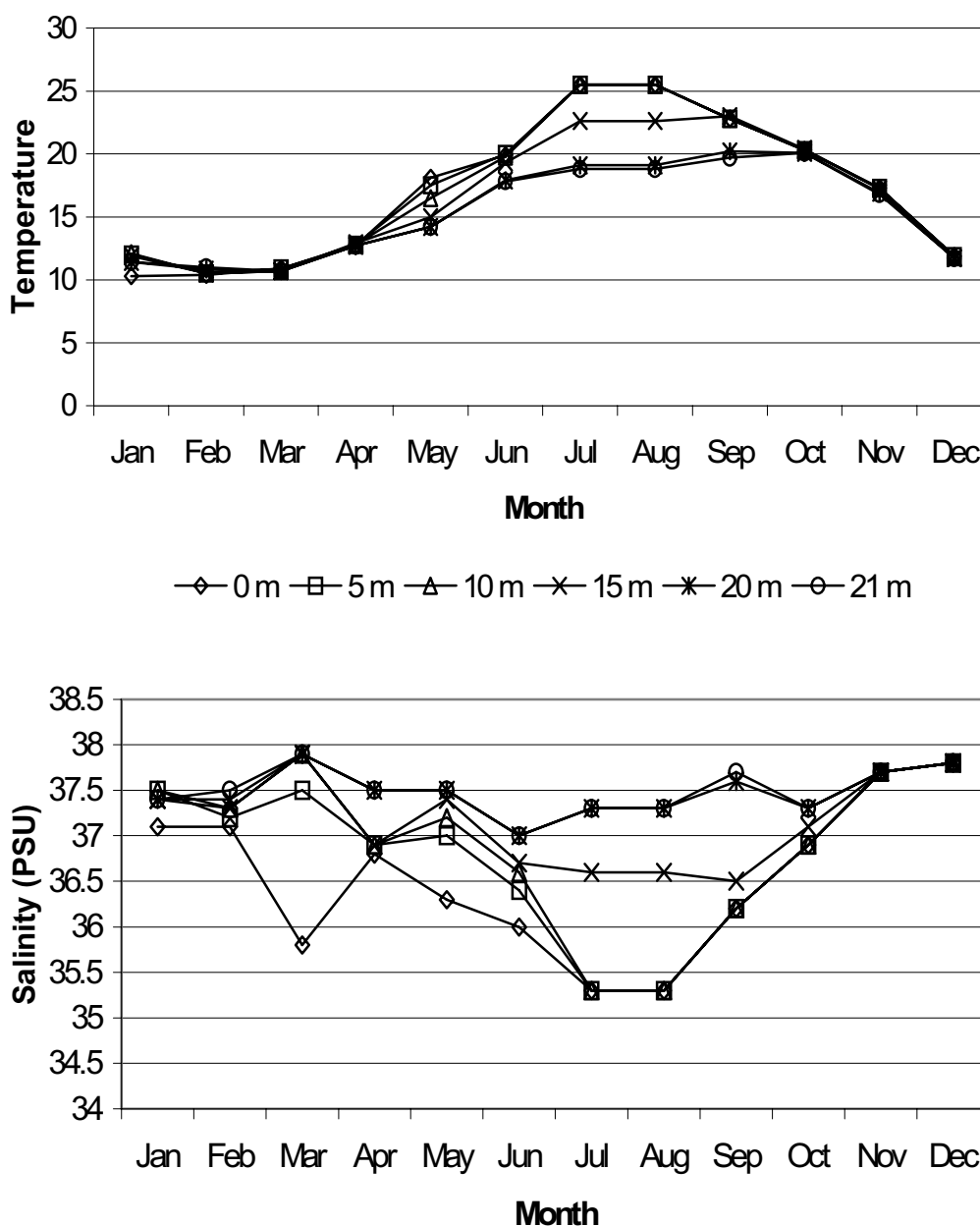


Fig. 1: Annual cycle of temperature (top) and salinity (bottom) at 5 depths during 2001.

Sl. 1: Letni potek temperature (zgoraj) in slanosti (spodaj) na petih globinah leta 2001.

Tab. 1: Gelatinous plankton species collected during 2001 in the southeastern part of the Gulf of Trieste**Tab. 1: Popis vrst želatinoznega planktona, najdenih l. 2001 v jugovzhodnem delu Tržaškega zaliva.**

Phylum	Class	Order	Family	Genus	Species
Cnidaria	Hydroidea	Anthomedusae	Corynidae	<i>Sarsia</i>	<i>S. gemmifera</i>
					<i>S. prolifera</i>
				<i>Dipurena</i>	<i>D. halterata</i>
			Zancleidae	<i>Zanclea</i>	<i>Z. costata</i>
			Hydractiniidae	<i>Podocoryne</i>	<i>P. carnea</i>
					<i>P. minuta</i>
					<i>P. minima</i>
					<i>P. spp.</i>
		Leptomedusae	Campanulariidae	<i>Obelia</i>	<i>O. spp.</i>
				<i>Phialidium</i>	<i>P. hemisphaericum</i>
			Eirenidae	<i>Helgicirrha</i>	<i>H. schultzei</i>
			Eutimidae	<i>Eutima</i>	<i>E. gracilis</i>
		Trachymedusae	Rhopalonematidae	<i>Aglaura</i>	<i>A. hemistoma</i>
		Narcomedusae	Solmaridae	<i>Solmaris</i>	<i>S. leucostyla</i>
					<i>S. vanhoeffeni</i>
					<i>S. spp.</i>
	Siphonophora	Calycophorae	Hippopodiidae	<i>Hippopodius</i>	<i>H. hippopus</i>
				<i>Vogtia</i>	<i>V. pentacantha</i>
			Diphyidae	<i>Muggiaea</i>	<i>M. kochi</i>
					<i>E. elongata</i>
					<i>M. atlantica</i>
			Sphaeronectidae	<i>Sphaeronectes</i>	<i>S. gracilis</i>
Chaetognatha				<i>Sagitta</i>	<i>S. setosa</i>
					<i>S. inflata</i>
					<i>S. spp.</i>
	Appendicularia		Oikopleuridae	<i>Oikopleura</i>	<i>O. dioica</i>
					<i>O. fusiformis</i>
					<i>O. longicauda</i>
					<i>O. vanhoeffeni</i>
			Fritillariidae	<i>Fritillaria</i>	<i>F. pellucida</i>
		Thaliacea	Doliolida	<i>Doliolum</i>	<i>D. gegenbauri</i>

Gelatinous plankton composition, abundance and seasonal distribution

The most diverse group of gelatinous plankton (Tab. 1) were Hydromedusae with 14 species, followed by Siphonophora (six species) and Appendicularia (five species). Chaetognatha were represented by two species, although numerous juvenile individuals could not be identified to the species level. Only one species of Thaliacea was determined. While most other gelatinous taxa are holoplanktonic, among the Hydromedusae meroplanktonic species prevailed.

Total abundance of all gelatinous taxa ranged from a minimum of 60 ind/m³ in autumn (October) to two peaks with slightly over 1000 ind/m³ in June and over 1300 ind/m³ in September. Generally, a higher total abundance of gelatinous organisms was recorded in the

warmer part of the year (May-September) with only a few species present throughout the year.

The most numerous gelatinous group (Fig. 2) were Appendicularia with the single species *Oikopleura longicauda* reaching abundances between 327 and 518 ind/m³ in the summer months. In the same period, another Appendicularian (*Oikopleura fusiformis*) was quite abundant (38 to 159 ind/m³), while *Oikopleura dioica* was more numerous in the colder months (February-April, max. in March 199 ind/m³). Among Hydromedusae, the most abundant species was *Podocoryne minuta* (max. 24 ind/m³ in June), followed by *Podocoryne minima*, which was also more numerous during the warm months from April to September (max. 19 ind/m³). In contrast, peak abundances of *Obelia* spp. were registered in the cold period (December - March, max. 21 ind/m³ in December). Other, numerically less copious (<

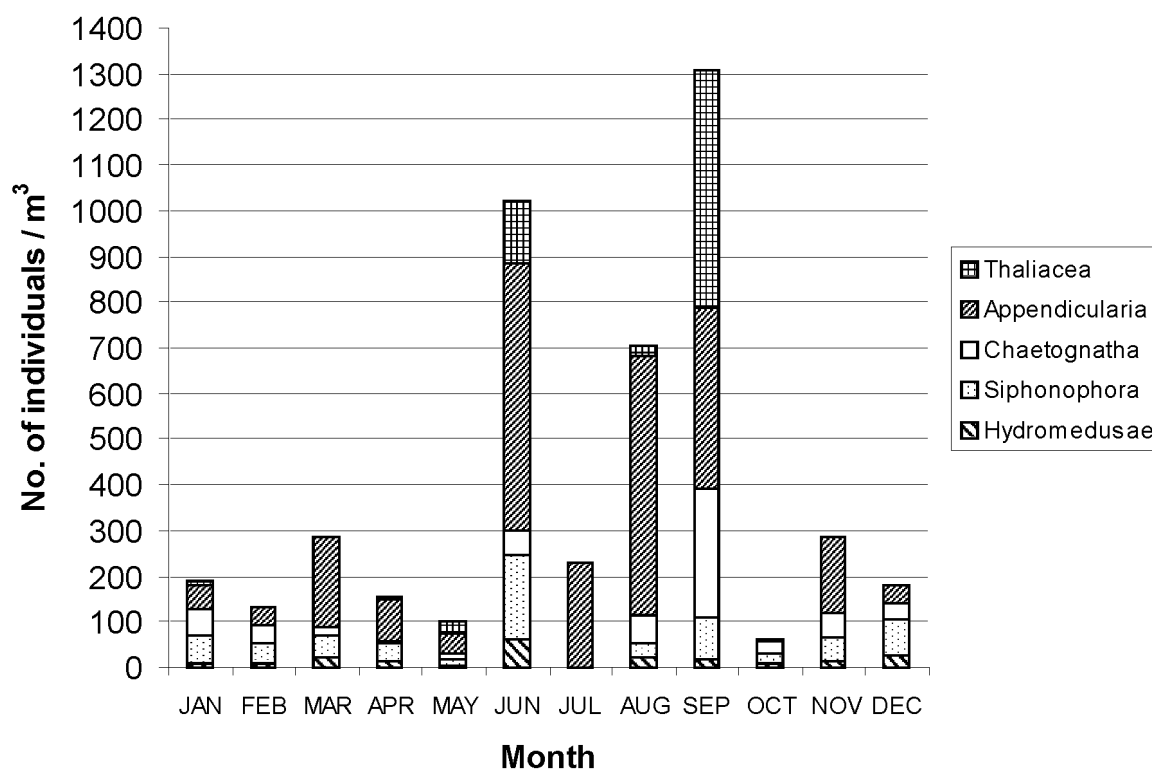


Fig. 2: Monthly abundance of the main gelatinous plankton groups during 2001 in the southeastern part of the Gulf of Trieste.

Sl. 2: Mesečne abundance skupin želatinoznega planktona leta 2001 v jugovzhodnem delu Tržaškega zaliva.

10 ind/m³) Hydromedusae species, were also associated with lower temperatures (November - April). Siphonophora, particularly two *Muggiaea* species, *M. kochi* and *M. atlantica*, were present throughout the year but showed two abundance peaks: in June (max. 84 ind/m³ for *M. atlantica* nectophore; max. 41 ind/m³ for *M. kochi*, nectophore) and September (max. 39 ind/m³ for *M. kochi*, gonophore). Chaetognatha were also present throughout the year, reaching maximal abundance in September (283 ind/m³), when individuals were almost entirely juvenile and thus not identified to the species level. Of the two species that were identified, *Sagitta setosa* was most abundant in June (16 ind/m³), whereas *Sagitta inflata* was registered only twice (in February and October). *Doliolum gegenbauri*, the only representative of Thaliacea, was found from March to November with peak abundance in September (518 ind/m³).

We used the Bray-Curtis similarity index to assess similarities among gelatinous assemblages in different months (Fig. 3). Using a similarity level of > 50 %, cluster analysis enabled us to distinguish three major groups of gelatinous assemblages over an annual cycle. Group B, typical of the cold period in transition to spring when the water column was vertically mixed (February-April), consisted of diverse Hydromedusae with species be-

longing to Leptomedusae, Trachymedusae and Narcomedusae, but very few Athomedusae. This period was also characterised by moderately abundant Siphonophora and Chaetognatha, while among Appendicularia only *O. dioica* was quite numerous. In contrast, group C, associated with the warm months and a vertically stratified water column (June, August-September), was characterized by the numerical dominance of Thaliacea (*D. gegenbauri*) and Appendicularia, the latter being represented by three species (*O. longicauda*, *O. fusiformis* and, to a lesser extent, *Oikopleura vanhoeffeni*), by important densities of Siphonophora that reached their annual peak during this period, and by an insignificant abundance of Hydromedusae, with the exception of Athomedusan *Podocoryne*. Group A comprised samples collected from November to January and was typified by rather high abundances of Siphonophora, which were represented by all six species registered in the studied area throughout 2001, by considerable abundances of Leptomedusae and *Aglaura hemistoma*, by moderate numbers of Appendicularia (*O. longicauda*, and, limited to this period of the year, *Fritillaria pellucida*). Certain months were distinguished at a similarity level of less than 50% (Fig. 3), and July was particularly isolated showing the lowest abundance of gelatinous organisms.

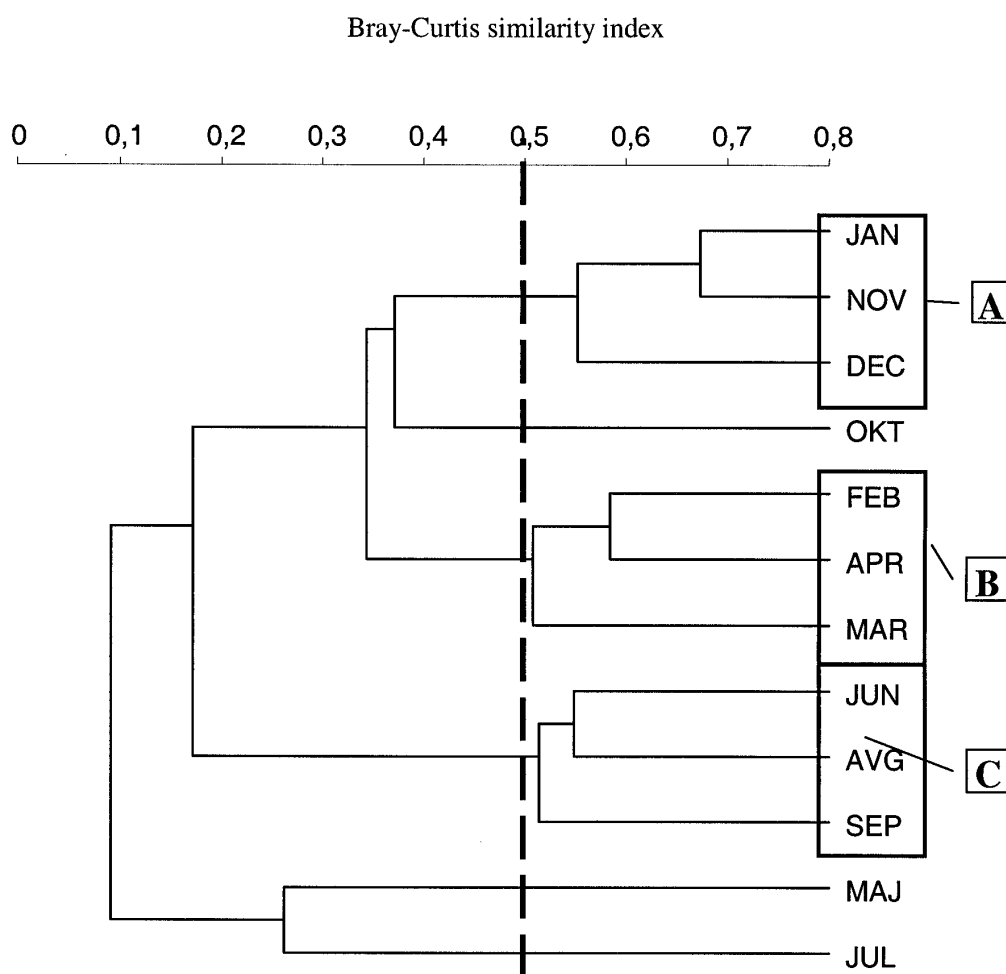


Fig. 3: Dendrogram of similarities (Bray-Curtis index) among gelatinous plankton assemblages (species list and abundance), collected in different months (see Tab. 1 for species list and Fig. 2 for abundances) of 2001.

Sl. 3: Dendrogram podobnosti (Bray-Curtisov indeks) želatinoznega planktona (vrstna sestava in abundance) za različne mesece (glej Tab.1 za popis vrst in Sl. 2 za abundance) v letu 2001.

Biomass of gelatinous organisms and their contribution to total zooplankton biomass

Due to their small size, high water content and the consequent low dry mass per individual, organisms had to be pooled into groups for biomass analyses. Dry mass, carbon and nitrogen content, and C/N (atomic) ratios of Hydromedusae, Siphonophora (mainly *M. kochi*), Chaetognatha (mainly *Sagitta* presumably *S. setosa* juv.) and Appendicularia (mainly *O. longicauda*) and Thaliacea (*D. gegenbauri*) are presented in Table 2. Carbon and nitrogen content varied widely: 7–34.4 and 1.4–7.9% of dry mass with the lowest values for Hydromedusae and the highest for Chaetognatha. C/N ratios were, in contrast, rather stable between 3.6 and 3.8, except for a slightly higher value for Hydromedusae.

Tab. 2: Carbon and nitrogen content and C/N ratio (atomic) of different gelatinous plankton groups.

Tab. 2: Vsebnost ogljika in dušika ter C/N razmerje (atomsko) različnih skupin želatinoznega planktona.

Group	% C	% N	C/N (atomic)
Hydromedusae	7.4	1.4	4.5
Siphonophora	34.3	7.9	3.7
Chaetognatha	34.4	7.9	3.7
Tunicata	31.9	7.4	3.6

The contribution of gelatinous organisms to total zooplankton biomass (on a dry weight basis) was below 8% throughout the year being the highest in November – December (Fig. 4) and above 5% also in June. Very low values (< 1%) were calculated for February and April – May. The contribution of different gelatinous taxa

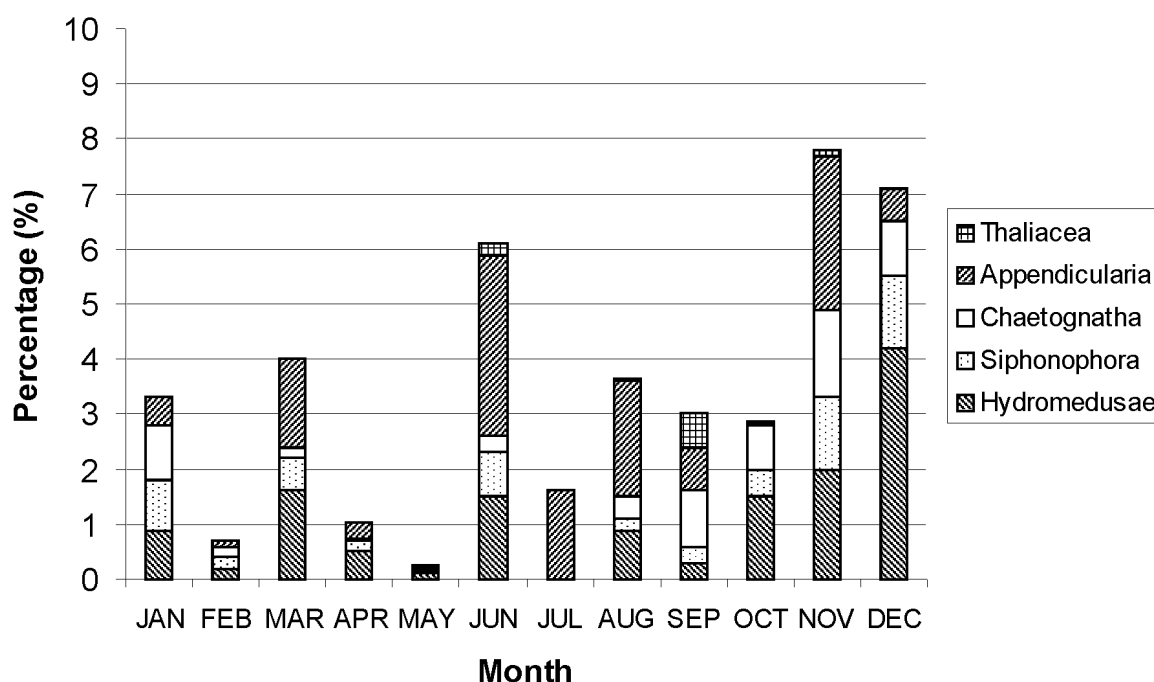


Fig. 4: Contribution of different gelatinous plankton groups to total zooplankton dry mass in different months of 2001 (expressed as %).

Sl. 4: Prispevki različnih skupin želatinoznega planktona k skupni suhi masi zooplanktona v različnih mesecih leta 2001 (izraženo kot %).

varied seasonally: Hydromedusae, Siphonophora and Chaetognatha contributed to a greater extent during the colder months, while Tunicates (Appendicularia and Thaliacea) contributed more during the warm season (Fig. 4).

DISCUSSION

Numbers of species for a particular taxonomic group of gelatinous plankton found during our one-year study are comparable to other studies in the Gulf of Trieste and, for most groups, to those from the wider northern Adriatic. For example, Benović *et al.* (2000) and Purcell *et al.* (1999) listed 14 Hydromedusae species in the northern Adriatic. The same number was found in this study. Rottini (1965) reported five Siphonophora species in the Gulf of Trieste, while our study showed six species, including the recently introduced species *Muggiaea atlantica* (Fig. 5) recorded in the Adriatic sea near Dubrovnik for the first time in 1995 (Gamulin & Kršinić, 2000; Kršinić & Njire, 2001). Moreover, *Vogtia pentacantha* (Fig. 6), a species characteristic for the Southern Adriatic and Mediterranean Sea, was found for the first time in the Gulf of Trieste. Two Chaetognatha species were found during our study, while Gamulin & Ghirardelli (1983) noted three species. In open northern Adriatic waters, Skaramuca (1983) found nine Appendicularian species compared to five found during our

study in the Gulf of Trieste. In addition, seasonal patterns of the main gelatinous taxa observed during our study conformed to the general picture from previous reports with one exception: during July 2001, the abundance of all gelatinous organisms was unusually low. We explain such a decline in abundance to the mucilage phenomenon, which, in 2001, was limited to a rather short period in late June – early July (*pers. obs.*).

The seasonal presence of different gelatinous taxa and their grouping into two clear clusters could be related to their preferences for abiotic factors as well as to their trophic position. Two distinct seasonal assemblages (February - April and June – August - September) with transitions were found. However, many gelatinous organisms found in the Gulf of Trieste in 2001 seemed to be eurythermal and present over a rather wide temperature range. Species that clustered in group C (Fig. 3), typical of warm months and stratified water column, included the most abundant gelatinous organisms in our study, Appendicularia *O. longicauda* and *O. fusiformis*. Potential prey for Appendicularians consists of pico and nano-sized organisms, including auto- and heterotrophic bacteria (Lopez-Urrutia *et al.*, 2003), although the clearing efficiency for picoplankton may be lower than that for larger prey (Scheinberg *et al.*, 2005). A similar trophic position is occupied by doliolids that most likely rely on soft-walled food particles, such as flagellates (Paffenhöfer & Köster, 2005). Other abundant gelatinous

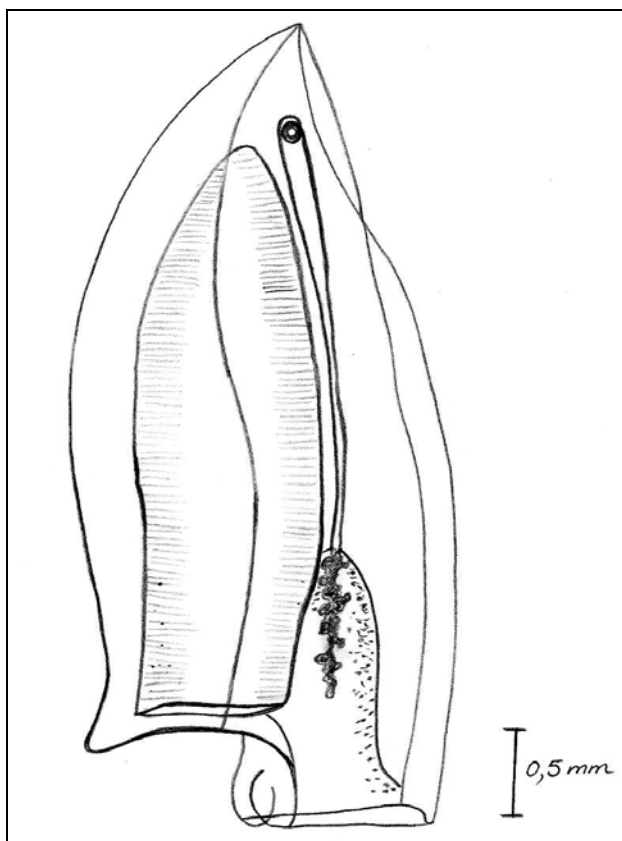


Fig. 5: *Muggiaea atlantica* (Diphyidae, Siphonophora) nectophore, a representative of the Atlantic fauna introduced in the Adriatic Sea in early 90-ties.

Sl. 5: *Muggiaea atlantica* (Diphyidae, Siphonophora) nektofor, predstavnik atlantske favne, vnešena v Jadransko morje v prvi polovici devetdesetih let.

organisms during the warm period included typical carnivorous organisms, such as *M. kochi* and *S. setosa*. The cold water group B, on other hand, was characterised by lower total abundances but more diverse gelatinous plankton, including hydromedusae that belonged to four subo. Anthomedusae, Leptomedusae, Tracymedusae and Narcomedusae, as well as Siphonophora and Chaetognatha. These organisms were traditionally viewed as top predators feeding on mesozooplankton. However, it has been recently shown that, for example, *Aglaura* was capable of feeding on prey ranging from green-pigmented protists to copepod nauplii (Colin *et al.*, 2005). The same authors predicted that many members of Hydromedusae could be expected to feed as omnivores.

Seasonal phytoplankton dynamics in the Gulf of Trieste in 2001 were rather typical of this region. Phytoplankton biomass and abundance reached their highest values in February (max. 4.99 µg Chl *a*/l, max. 2.4×10^6 cells/l) due to a bloom of diatoms, particularly *Pseudo-*

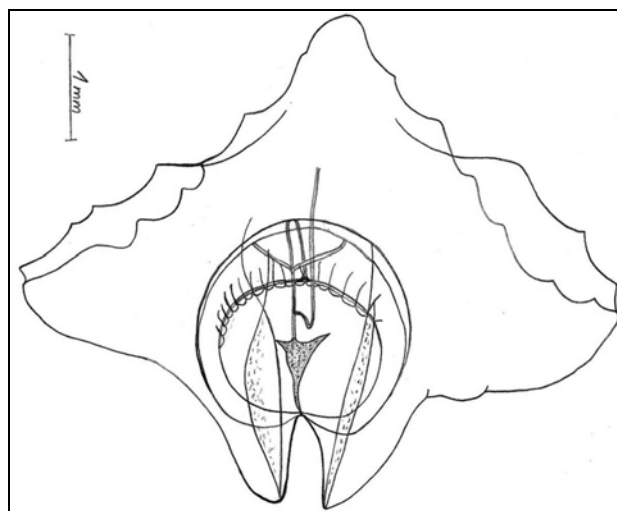


Fig. 6: *Vogtia pentacantha* (Hippopodiidae, Siphonophora) nectophore, species characteristic for deep waters found in the southern Adriatic.

Sl. 6: *Vogtia pentacantha* (Hippopodiidae, Siphonophora) nektofor, tipična globokomorska vrsta, značilna za južnojadransko kotlino.

nitzschia pungens, which constituted over 80% of the diatom population (Mozetič & Lipej, 2002). Gelatinous zooplankton are not likely to be able to prey efficiently on this chain-forming diatom, which is consistent with their low abundance (see Fig. 2) as well as their contribution to zooplankton dry mass (Fig. 4). Phytoplankton biomass was lower in late spring-summer (min. 0.36 µg Chl *a*/l, $< 3.0 \times 10^5$ cells/l) and autumn ($< 2.0 \times 10^5$ cells/l), when small flagellates, including coccolitophorids and silicoflagellates, prevailed. During this period, autotrophic and heterotrophic bacteria also reach their annual peak abundance (Turk *et al.*, 2001, Fonda Umani & Beran, 2003). All these organisms represent potential prey for Appendicularians and doliolids, and indeed, from June to September pelagic tunicates reached their maximal abundance. Naked ciliates, copepod nauplia and copepodites, as other potential food sources for some gelatinous taxa, attained abundance peaks in June and September (Mozetič & Lipej, 2002), when in addition to pelagic tunicates, Hydromedusae, Siphonophora and Chaetognatha were also numerous.

Published data on the carbon and nitrogen content of gelatinous organisms are scarce, and different authors reported very different contents. Part of this variability might be attributed to bound water and the drying procedure. Also, the relative proportion of gonads, which are characterized by higher carbon and nitrogen contents compared to the rest of the gelatinous body (Larson, 1986), may influence results. Our data are within ranges published for different gelatinous taxa (Clarke *et al.*, 1992; Postel *et al.*, 2000). Values were on the low

side for Hydromedusae and higher for other gelatinous taxa, particularly for Chaetognatha, which Larson (1986) considered semi-gelatinous. Based on these values and their contribution to total zooplankton biomass on a dry weight basis ($< 10\%$), we could conclude that small gelatinous organisms played a minor trophic role during the period of our study, particularly during the months when copepods dominated the mesozooplankton community (winter – spring). Their role was more significant in the stratified water column, when pelagic tunicates preyed on pico and nano-sized autotrophs and hetero-

trophs that were abundant at that time. Carnivorous gelatinous groups and species (Siphonophora, Chaetognatha) were more important in late autumn.

ACKNOWLEDGEMENTS

We thank the crew of the Sagita for their help during field surveys; Drs Branko Čermelj and Nives Kovač for their help with elemental analyses; Drs Adam Benović and Davor Lučić for taxonomic guidance, and Milijan Šiško for advice with statistical analysis.

SEZONSKA NIHANJA ŽELATINOZNEGA ZOOPLANKTONA V OBALNIH VODAH (TRŽAŠKI ZALIV, JADRANSKO MORJE)

Čarna MILOŠ

SI-6281 Škofije, Spodnje Škofije 140

Alenka MALEJ

Morska biološka postaja, Nacionalni inštitut za biologijo, SI-6330 Piran, Fornače 41

E-mail: malej@mbss.org

POVZETEK

Avtorici poročata o sestavi, abundanci, biomasi in sezonskih nihanjih želatinoznega zooplanktona v teku letnega ciklusa v Tržaškem zalivu (Jadransko morje). Z največ vrstami so bile zastopane hidromeduze (14), ki so jim sledili cevkaši (6 vrst), repati plaščarji (5 vrst), ščetinočeljustnice (2 vrsti) in 1 vrsta salp. Tujerodna vrsta cevkašev Muggiaea atlantica je bila prvič registrirana za Tržaški zaliv. Vsebnost ogljika v suhi masi želatinoznih organizmov je nihala med 7,4 in 34,4%, dušika pa med 1,4 in 7,9%. Prispevek želatinoznih organizmov k suhi masi celotnega zooplanktona je bil najvišji pozno jeseni, vendar ni nikoli presegal 8%. Klastrska analiza (Bray-Curtisov podobnostni indeks) je nakazala grupiranje v tri skupine. Obdobje nizkih temperatur in prehod na pomlad opredeljuje pestra združba hidromeduz, zmerne abundance cevkašev in redki repati plaščarji. V združbi toplih mesecev številčno prevladujejo pelaški plaščarji (Thaliacea in Appendicularia), številni sta dve vrsti cevkašev, hidromeduze pa so maloštevilne. Značilnost tretje skupine (obdobje november – januar) so dokaj nizke abundance in vrstno pestra sestava želatinoznih organizmov.

Ključne besede: želatinozni zooplankton, sezonska dinamika, obalne vode, Jadransko morje

REFERENCES

Acuña, J. L. (2001): Pelagic tunicates: why gelatinous? *Am. Nat.*, 158(1), 11–107.
Arai, M. N. (2005): Predation on pelagic coelenterates: a review. *J. Mar. Biol. Ass. U.K.*, 85, 523–536.
Batistić, M., F. Kršinić, N. Jasprica, M. Carić, D. Viličić & D. Lučić (2004): Gelatinous invertebrate zooplankton of the South Adriatic: species composition and vertical distribution. *J. Plankton Res.*, 26, 459–474.

Benović, A., D. Lučić & V. Onofri (2000): Does change in an Adriatic Hydromedusan Fauna indicate and Early Physe of Marine Ecosystem Destruction? *P.S.Z.N.I.: Mar. Ecol.*, 21, 221–231.
CIESM (2001): Gelatinous zooplankton outbreaks: theory and practice. CIESM Workshop. Series 14, Monaco, 104 pp.
Clarke, A., L. J. Holmes, & D. J. Gore (1992): Proximate and elemental composition of gelatinous zooplankton from Southern Ocean. *J. Exp. Mar. Biol. Ecol.*, 155, 55–68.

- Colin, S. P., J. H. Costello, W. M. Graham & J. Higgins III (2005):** Omnivory by the small cosmopolitan hydromedusa *Aglaura hemistoma*. *Limnol. Oceanogr.*, 50, 1264–1268.
- Field, J. G., K. R. Clarke & R. M. Warwick (1983):** A practical strategy for analysing multispecies distribution patterns. *Mar. Ecol. Prog. Ser.*, 8, 37–52.
- Fonda Umani, S., S. C. Young, E. Feoli, B. Cataletto, M. Carbini & L. Milani (1995):** Is it possible to identify any plankton succession in the Gulf of Trieste (northern Adriatic)? In: Elefteriou, A., A. D. Ansell & C. J. Smith (eds.): *Biology and Ecology of Shallow Coastal Waters*. Proc. 28th EMBS, p. 39–65.
- Fonda Umani, S. & A. Beran (2003):** Seasonal variations in the dynamics of microbial plankton communities: first estimates from experiments in the Gulf of Trieste. *Mar. Ecol. Prog. Ser.*, 247, 1–16.
- Gamulin, T. & E. Ghirardelli (1983):** Les chaetognathes de la mer Adriatique. *Rapp. Comm. int. Mer Médit.*, 28, 175–177.
- Gamulin, T. & F. Kršinić (2000):** Kalikofore (Siphonophora, Calycophorae) Jadranskog i Sredozemnog mora. *Nat. Croat.*, 9(suppl. 2), 1–198.
- Harding, L. W., D. Degobbi & R. Precali (1999):** Production and Fate of Phytoplankton: Annual Cycles and Interannual Variability. In: Malone, T. C., A. Malej, L. W. Harding, N. Smodlaka & E. R. Turner (eds.): *Ecosystems at the Land-Sea Margin. Drainage Basin to Coastal Sea*. Coastal and Estuarine Studies 55, AGU, Washington DC, p. 131–172.
- Kršinić, F. & J. Njire (2001):** An invasion by *Muggiaea atlantica* Cunningham 1982 in the northern Adriatic Sea in the summer of 1997 and the fate of small copepods. *Acta Adriat.*, 41, 49–59.
- Larson, R. J. (1986):** Water content, organic content, and carbon and nitrogen composition of medusae from the northeast Pacific. *J. Exp. Mar. Biol. Ecol.*, 99, 107–120.
- Lopez-Urrutia, A., X. Irigoien, J. L. Acuña & R. P. Harris (2003):** *In situ* feeding physiology and grazing impact of the appendicularian community in temperate waters. *Mar. Ecol. Prog. Ser.*, 252, 125–141.
- Malej, A., P. Mozetič, V. Malačič, S. Terzić & M. Ahel (1995):** Phytoplankton responses to freshwater inputs in a small semi-enclosed gulf (Gulf of Trieste, Adriatic Sea). *Mar. Ecol. Prog. Ser.*, 120, 111–121.
- Malej, A., V. Turk, D. Lučić & A. Benović (submit.):** Direct and indirect trophic interactions of *Aurelia* sp. (Scyphozoa) in a stratified marine environment (Mljet Lakes, Adriatic Sea). *Mar. Biol.*
- Mianzan, H., M. Pajaro, G. Alvarez Colombo & A. Madirolas (2001):** Feeding on survival food: gelatinous plankton as a source of food for anchovies. *Hydrobiologia*, 451, 45–53.
- Mills, C. E. (1995):** Medusae, siphonophores, and ctenophores as planktivorous predators in changing global ecosystems. *ICES J. Mar. Sci.*, 52, 575–581.
- Mozetič, P., S. Fonda Umani, B. Cataletto & A. Malej (1998):** Seasonal and interannual plankton variability in the Gulf of Trieste (northern Adriatic). *ICES J. Mar. Sci.*, 55, 711–722.
- Mozetič, P. & L. Lipej (2002):** Izvajanje monitoringa kakovosti morja za leto 2001. Zaključno poročilo. Nacionalni inštitut za biologijo, Morska biološka postaja, Piran, 84 str. (in slov.)
- Paffenhöfer, G.-A. & M. Köster (2005):** Digestion of diatoms by planktonic copepods and doliolids. *Mar. Ecol. Prog. Ser.*, 297, 303–310.
- Pella, E. & B. Colombo (1978):** Simultaneous C-H-N and S microdetermination by combustion and gas chromatography. *Microchimica Acta*, 1, 271–286.
- Postel, L., H. Fock & W. Hagen (2000):** Biomass and abundance. In: Harris, R. P., P. H. Wiebe, J. Lenz, H. R. Skjoldal & M. Huntley (eds.): *ICES Zooplankton Methodology Manual*, p. 83–192.
- Purcell, J., A. Malej & A. Benović (1999):** Potential links of jellyfish to eutrophication and fisheries. In: Malone, T. S., A. Malej, L. W. Harding, N. Smodlaka & E. R. Turner (eds.): *Ecosystems at the Land-Sea Margin. Drainage Basin to Coastal Sea*. Coastal and Estuarine Studies 55, AGU, Washington DC, p. 241–263.
- Riemann, L., J. Titelman, P. Griekspoor, U. Bamstedt (2005):** Plankton community structure and bacterial community composition in a Norwegian fjord dominated by medusa *Periphylla periphylla*. ASLO Conference. Book of Abstracts, p. 129.
- Roman, M., X. Zhang, C. McGillard & W. Boicourt (2005):** Seasonal and annual variability in spatial patterns of plankton biomass in Chesapeake Bay. *Limnol. Oceanogr.*, 50, 480–492.
- Rottini, L. (1965):** Sifonofori e Medusae del Golfo di Trieste. *Boll. Zool.*, 32, 619–637.
- Skaramuca, B. (1983):** Quantitative and qualitative distribution of Appendicularian populations in the open waters of the Adriatic Sea. *Acta Adriat.*, 24, 133–177.
- Scheinberg, R. D., M. R. Landry & A. Calbet (2005):** Grazing of two common appendicularians on the natural prey assemblage of a tropical coastal ecosystem. *Mar. Ecol. Prog. Ser.*, 294, 201–212.
- Sneath, P. H. A. & R. R. Sokal (1973):** Numerical taxonomy – the principles and practice of numerical classification. W.H. Freeman & Co., San Francisco.
- Turk, V., P. Mozetič & A. Malej (2001):** Seasonal variability in phytoplankton and bacterioplankton distribution in the semi-enclosed temperate Gulf (Gulf of Trieste, Adriatic Sea). *Annales, Ser. hist. nat.*, 11(1), 53–64.
- Valiela, I. (1995):** *Marine Ecological Processes*. 2nd ed. Springer-Verlag, New York, 686 pp.

review article
received: 2005-04-15

UDK 597.5 (262.3)

AN ANNOTATED CHECKLIST OF THE FAMILY GOBIIDAE IN THE ADRIATIC SEA

Marcelo KOVAČIĆ

Natural History Museum Rijeka, HR-51000 Rijeka, Lorencov prolaz 1, Croatia
E-mail: Marcelo.Kovacic@public.srce.hr

ABSTRACT

An annotated checklist of the gobies of the Adriatic Sea is presented, including 46 species. All available data concerning the presence of gobiid species in the Adriatic Sea are compiled and critically re-examined.

Key words: check-list, Gobiidae, Adriatic Sea

LISTA AGGIORNATA DELLA FAMIGLIA GOBIIDAE IN MARE ADRIATICO

SINTESI

L'articolo presenta una lista aggiornata dei gobiidi del mare Adriatico, completa di 46 specie. Vengono forniti e riesaminati con criterio critico tutti i dati disponibili inerenti la presenza delle specie di gobiidi in Adriatico.

Parole chiave: lista, Gobiidae, mare Adriatico

INTRODUCTION

The first published data on gobies of the Adriatic Sea was the record of *Gobius jozo* for the Split and Trogir areas (the synonym of *Gobius niger* Linnaeus, 1758) published in the book «Ichthyologia massiliensis» Brünich (1765). Numerous lists of the Adriatic fish species during the following two centuries also included gobiid species (Štević, 1977). However, the authors of these lists were not gobiologists, in the 19th century often not even ichthyologists. These papers were rarely written by specialists on original material, and numerous lists contained just the species name, while some, in addition, contained general comments on the species (Carrara, 1846; A. Stossich, 1869; Canestrini, 1872; M. Stossich, 1880; Faber, 1883; Brusina, 1891; Sucker, 1895; Grifini, 1903; E. Ninni, 1912; Šoljan, 1948, 1965; Jardas, 1985). The names of gobiid species were cited by rote from one list to another. These lists, due to unclear synonymy, also included non-valid names and names of species whose presence in the Adriatic Sea could not be proved. Only several lists were orientated just on gobies (Kolombatović, 1891; A. P. Ninni, 1882; Damiani, 1896; E. Ninni, 1938; Cavinato, 1952; Kovačić, 1994).

The synonymy of Mediterranean gobies was cleared by Miller (1973a). Štević (1977), using the synonymy of Miller (1973a), listed 40 gobiid species of the Adriatic Sea. This number was later increased by the reviews of Kovačić (1994) - 42 species, and Jardas (1996a) - 44 species, due to original papers published in the meantime. Recent years have been a dynamic period for the Adriatic gobiology. Therefore, the review of Lipej & Dulčić (2004), among other fishes, listed new gobiid species found in the Adriatic Sea since Jardas (1996a), and they concluded that, with 50 species, gobies are the best represented fish family in the Adriatic Sea. However, all these authors avoided critical reconsideration of the presence of species that were previously included in the Adriatic fauna. The only exception is the replacement of *Vanneaugobius pruvoti* (Fage, 1907) in Jardas (1996a) with *Vanneaugobius dollfusi* Brownell, 1978 by Lipej & Dulčić (2004). However, this is the result of an in-between published paper on re-examined specimens by Pallaoro & Kovačić (2000). The scope of the present paper is to give complete, actual list of gobiid species in the Adriatic Sea based on critical re-examination of all available data concerning the presence of gobiid species in the Adriatic Sea.

MATERIAL AND METHODS

This review was based on scientific literature and on unpublished data on ichthyological collection of the Natural History Museum Rijeka and on ichthyological collection of the Center for Marine Research Rovinj. The gobiid species are considered to be present in the Adri-

atic Sea if the following conditions are met: Adriatic specimens of these species are deposited in the collections, or the published descriptions of Adriatic specimens contained enough morphological data for positive identification. The mentioned criteria prevent that once wrongly cited species for the Adriatic Sea would repeatedly to be listed as the part of the Adriatic fauna. The published data on species previously listed for the Adriatic Sea that should be excluded from the Adriatic fauna are critically examined. The annotation for each species contained bibliography of published records of the species in the Adriatic Sea, and of preserved specimens in the collections. The localities of the published records were listed along the Adriatic Sea in north-south direction. All records of gobiid species already known for the Adriatic Sea but difficult for identification are considered to be without positive identification, if specimens were not described, deposited, or checked *in situ* by fish taxonomist.

CHECKLIST

The presented checklist contains 46 gobiid species recorded in the Adriatic Sea up to the present date (Tab. 1).

***Aphia minuta mediterranea* De Buen, 1931**

Gobius Aphyia: Naccari, 1822; Martens, 1838.

Gobius pellucidus: Nardo, 1827; Kolombatović, 1891.

Brachyochirus prototypes: Nardo, 1860.

Brachyochirus aphyia: Trois, 1875.

Latrunculus pellucidus: Giglioli, 1880; Kolombatović, 1881, 1882; A. P. Ninni, 1882.

Gobius albus: Graeffe, 1888.

Aphia pellucida: D'Ancona, 1922; Zei, 1942, 1949.

Brachyochirus pellucidus: Županović, 1961; Marcuzzi, 1972.

Aphia minuta mediterranea: Jardas *et al.*, 1996; Pallaoro & Jardas, 1996.

Aphia minuta: Froglija & Gramitto, 1989; Ungaro *et al.*, 1994; Nocita & Vanni, 1997; Kovačić, 1998, 2003; La Mesa, 1999; Sorice & Caputo, 1999; Caputo *et al.*, 2000; Zavodnik & Kovačić, 2000; Crnković, 2001.

The species was first reported in the Adriatic Sea for the Venice Lagoon under the synonym *Gobius Aphyia* (Naccari, 1822). The species was listed under various synonyms for the Venice Lagoon, the Gulf of Trieste, the Rijeka Bay, the Kvarner area, Dalmatia, the Split area, and Dubrovnik (Nardo, 1827, 1860; Martens, 1838; Trois, 1875; Giglioli, 1880; Kolombatović, 1881, 1882, 1891; A. P. Ninni, 1882; Graeffe, 1888; D'Ancona, 1922; Zavodnik & Kovačić, 2000). The specimens from Trieste, the Kvarner area, the Šolta Island, and Dubrovnik

are deposited in the collection of the Natural History Museum Rijeka, in the collection of Museo di Storia Naturale dell' Università di Firenze, in the collection of Stazione Idrobiologica di Chioggia, and in the collection of the Institute of Oceanography and Fisheries, Split (Marcuzzi, 1972; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, 1998, 2003, unpublished data). Specimens were collected by the small scale fishery gear in the Kvarner area, the Kornati Islands, and the Murter Sea (Jardas *et al.*, 1996; Crnković, 2001), and by the trawl in the northern Adriatic, in the channels between the mid-Dalmatian islands, in the central Adriatic, and in the Manfredonia area (Zei, 1942, 1949; Županović, 1961; Frogia & Gramitto, 1989; Ungaro *et al.*, 1994). The samples of this species were also collected at Ortona and Ancona (central Adriatic Sea) (La Mesa, 1999; Sorice & Caputo, 1999; Caputo *et al.*, 2000).

***Buenia affinis* Iljin, 1930**

Buenia affinis: Kovačić, 2002a.

It was considered for a long time that the species was described in the Adriatic Sea by Kolombatović (1891). The discovery of Miller (1972a) that Kolombatović's syntypes in the collection of the Naturhistorischen Museum, Wien belong to another species, *Pomatoschistus pictus*, were ignored in later reviews. In these reviews the species was treated as present in the Adriatic Sea (Tortonese, 1975; Štević, 1977; Kovačić, 1994; Jardas, 1996a), or as a junior synonym of other valid species (E. Ninni, 1938; Šoljan, 1948; Cavinato, 1952; Bini, 1969). Kovačić (2002a) finally collected true specimens of *B. affinis* in 1996 and 1997 in the Kvarner area. The specimens from the Kvarner area and Seline (the Velebit Channel) are deposited in the collection of the Natural History Museum Rijeka (Kovačić, unpublished data). Visual census research recorded the species at Kostrena, the Rijeka Bay (Kovačić, 2002b).

***Chromogobius quadrivittatus* (Steindachner, 1863)**

Gobius quadrivittatus: Steindachner, 1863; Graeffe, 1888.

Gobius planiceps: Bellotti, 1879.

Gobius quadrivittatus=*Gobius planiceps*: Kolombatović, 1881, 1882, 1886.

Gobius planiceps v. *quadrivittata*: Kolombatović, 1891.

Chromogobius quadrivittatus: Miller, 1971; Ahnelt, 1990; Zavodnik & Crnković, 1992; Kovačić, 1994, 1997, 1998, 2002b; Jardas *et al.*, 1996, 1998; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Zavodnik & Kovačić, 2000.

The species was described by Steindachner (1863)

on the specimens collected at the Hvar Island. The species was listed for Venice, Trieste, the Rijeka Bay, the Hvar Island, and the Split area (Perugia, 1866; Bellotti, 1879; Kolombatović, 1881, 1882, 1886, 1891; A. P. Ninni, 1882; Graeffe, 1888; Kovačić, 1994; Jardas *et al.*, 1998; Zavodnik & Kovačić, 2000). The specimens from Trieste, Rovinj, the Kvarner area, the Hvar Island, and the Split area are deposited in the collection of the Natural History Museum Rijeka, in the collection of the Naturhistorisches Museum Wien, and in the collection of the Institute of Oceanography and Fisheries, Split (Miller, 1971; Ahnelt, 1990; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, 1997, 1998, unpublished data). The species was also recorded at numerous localities in the Kvarner area (Zavodnik & Crnković, 1992; Kovačić, 1997, 2002b). Specimens were collected by the small scale fishery gear at the Kornati Islands and the Murter Sea (Jardas *et al.*, 1996). Visual census research recorded the species at Kostrena, the Rijeka Bay (Kovačić, 2002b).

***Chromogobius zebratus zebratus* (Kolombatović, 1891)**

Gobius planiceps zebrata: Kolombatović, 1891.

Chromogobius zebratus zebratus: Miller, 1971; Kovačić, 1994.

Chromogobius zebratus: Ahnelt, 1990; Kovačić, 1997, 1998; Jardas *et al.*, 1998; Zavodnik & Kovačić, 2000.

The species was described by Kolombatović (1891) on the specimens collected in the Split area. The specimens from the Kvarner area (the northern Adriatic Sea), the Šolta Island, the Split area, and from Mala Duba (the central Adriatic Sea) are deposited in the collection of the Natural History Museum Rijeka, and in the collection of the Naturhistorisches Museum Wien (Miller, 1971; Ahnelt, 1990; Kovačić, 1997, 1998, unpublished data; Zavodnik & Kovačić, 2000). The species was also recorded at numerous localities in the Kvarner area (Kovačić, 1994, 1997; Jardas *et al.*, 1998).

***Corcyrogobius liechtensteini* (Kolombatović, 1891)**

Gobius liechtensteini: Kolombatović, 1891 (*part.*).

Corcyrogobius liechtensteini: Miller, 1972b; Kovačić, 1997, 1998; Arko Pijevac *et al.*, 2001.

The species was described by Kolombatović (1891) on the specimens collected in the Split area. The additional specimens at Split were collected also by Kolombatović (1895). The specimens from the Kvarner area (the northern Adriatic Sea), from Mala Duba, and the Korčula Island (the central Adriatic Sea) are deposited in the collection of the Natural History Museum Rijeka and in the collection of the Naturhistorisches Museum Wien (Miller, 1972b; Kovačić, 1997, 1998, unpublished data).

Benthic biocoenological research recorded the species in the Kvarner area (Arko Pijevac *et al.*, 2001).

***Crystallogobius linearis* (Von Düben, 1845)**

Crystallogobius Nilssonii: Kolombatović, 1900.
Crystallogobius nilsoni: Županović & Grubišić, 1958; Županović, 1961.
Crystallogobius Nilsoni: Jukić & Crnković, 1974.
Crystallogobius linearis: Županović & Jardas, 1989; Pallaoro & Jardas, 1996; Kovačić, 1998; La Mesa, 2001; Caputo *et al.*, 2003.

The species was first reported in the Adriatic Sea for Dalmatia (Kolombatović, 1900). The specimens from the central Adriatic Sea and the Split area are deposited in the collection of the Natural History Museum Rijeka and in the collection of the Institute of Oceanography and Fisheries, Split (Pallaoro & Jardas, 1996; Kovačić, 1998). Specimens were collected by the bottom trawl in the channels of the north-eastern Adriatic Sea, the Jabuka Pit, near Rogoznica, and in the channels between the mid-Dalmatian islands (Županović & Grubišić, 1958; Županović, 1961; Jukić & Crnković, 1974; Županović & Jardas, 1989), without a positive identification. The samples of this species were also collected at Ortona (central Adriatic Sea) (La Mesa, 2001; Caputo *et al.*, 2003).

***Deltentosteus colonianus* (Risso, 1826)**

Gobius Liechtensteinii: Steindachner, 1883.
Gobius colonianus: Steindachner & Kolombatović, 1884; Kolombatović, 1886, 1891.
Deltentosteus colonianus: Jardas *et al.*, 1996; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, 1998.

The species was first reported in the Adriatic Sea for the Šolta Island by Steindachner (1883). The additional specimens from the Split area were reported by Steindachner & Kolombatović (1884) and Kolombatović (1886, 1891). The specimens from the Kvarner area, the Vrgada Island, the Šolta Island, the Hvar Channel, and the Split area are deposited in the collection of the Natural History Museum Rijeka, in the collection of Museo di Storia Naturale dell' Università di Firenze, and in the collection of the Institute of Oceanography and Fisheries, Split (Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, 1998, *unpubl. data*). Specimens were collected by the small scale fishery gear at the Kornati Islands and the Murter Sea (Jardas *et al.*, 1996).

***Deltentosteus quadrimaculatus* (Valenciennes, 1837)**

Gobius marsio: Nardo, 1827, 1860.

Gobius quadrimaculatus: Perugia, 1866, 1881; Trois, 1875; Kolombatović, 1881, 1882, 1891; A. P. Ninni, 1882; Zei, 1942, 1949; Županović, 1961; Crnković, 1970.

Deltentosteus quadrimaculatus: Jukić & Crnković, 1974; Jukić, 1975, 1983; Gamulin-Brida *et al.*, 1980; Županović & Jardas, 1989; Cetinić & Pallaoro, 1990b; Jardas, 1996b; Jardas *et al.*, 1996, 1998; Pallaoro & Jardas, 1996; Špan *et al.*, 1996; Nocita & Vanni, 1997; Kovačić, 1998; Zavodnik & Kovačić, 2000.

Deltentosteus (Gobius) quadrimaculatus: Usić, 2003.

The species was first reported in the Adriatic Sea for the Venice Lagoon under the synonym *Gobius marsio* (Nardo, 1827). Miller (1973a) doubted regarding identity of *G. marsio* in Nardo (1827). However, Nardo (1860) itself mentioned "*G. quadrimaculatus*, Valenc." as synonym of his *G. marsio*. The species was listed for the Venice Lagoon, Trieste, Istria, the Kvarner area, and the Split area (Nardo, 1860; Perugia, 1866, 1881; Trois, 1875; Kolombatović, 1881, 1882, 1891; A. P. Ninni, 1882; Zavodnik & Kovačić, 2000). The specimens from Venice, Rovinj, Istria, the Kvarner area, the Split area, the Lastovo Channel, the Kaštela Bay, the Mali Ston Bay, the Murter Island, and Bari are deposited in the collection of the Center for Marine Research of the Ruđer Bošković Institute in Rovinj, in the collection of the Natural History Museum Rijeka, in the collection of Museo di Storia Naturale dell' Università di Firenze, and in the collection of the Institute of Oceanography and Fisheries, Split (Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, 1998, *unpubl. data*; Usić, 2003). Specimens were collected by the small scale fishery gear at the Kornati Islands and the Murter Sea, northern and central Dalmatia (Cetinić & Pallaoro, 1990b; Jardas *et al.*, 1996), and by the bottom trawl in the northern Adriatic, the Kvarner area, the channels of the north-eastern Adriatic Sea, the Jabuka Pit, the central Adriatic, the channels between the mid-Dalmatian islands, the Murter Sea, and Crnogorsko primorje (Zei, 1942, 1949; Županović, 1961; Crnković, 1970; Jukić & Crnković, 1974; Jukić, 1975, 1983; Županović & Jardas, 1989; Jardas, 1996b; Jardas *et al.*, 1998; Špan *et al.*, 1996). Benthic biocoenological research recorded the species at the Krk Island (Gamulin-Brida *et al.*, 1980).

***Didogobius schlieveni* Miller, 1992**

Didogobius schlieveni: Miller, 1992.

The species was described by Miller (1992) on the single male collected at the Unije Island, near the Cres Island, the Kvarner area on 26 June 1991. The holotype is deposited in the collection of the Zoologische Staatssammlung, München. Three additional specimens in the

Adriatic Sea were collected at the Krk Island (the Kvarner area), at the Šolta Island, and the Ugljan Island (the central Adriatic) (Pallaoro & Jardas, 1996; Kovačić, *unpubl. data*). These specimens are deposited in the collection of the Natural History Museum Rijeka and in the collection of the Institute of Oceanography and Fisheries, Split.

***Didogobius splechnai* Ahnelt & Patzner, 1995**

Didogobius splechnai: Herler & Patzner, 2002.

Single subadult was collected for the first time in the Adriatic Sea near Pula (the Istrian Peninsula) on 3 June 2001 (Herler & Patzner, 2002). The specimen is deposited in the collection of the Naturhistorisches Museum Wien.

***Gammogobius steinitzi* Bath, 1971**

Gammogobius steinitzi: Kovačić, 1999.

Two females were collected for the first time in the Adriatic Sea in the Vrbnik cave, at the Krk Island (the Kvarner area) on 16 October 1998 (Kovačić, 1999). The additional nine specimens were collected at the same locality on 9 and 13 September 1999 (Kovačić, *unpubl. data*). They all are deposited in the collection of the Natural History Museum Rijeka.

***Gobius ater* Bellotti, 1888**

Gobius ater: Ahnelt, 2001.

Three males, collected by Kolombatović at Split (the central Adriatic), were found in the collection of the Naturhistorisches Museum Wien and identified by Ahnelt (2001).

***Gobius auratus* Risso, 1810**

Gobius auratus: Perugia, 1866, 1881; Trois, 1875; Giglioli, 1880; Kolombatović, 1881, 1882, 1891; Perugia, 1881; A. P. Ninni, 1882; Faber, 1883; Vinciguerra, 1883; Damiani, 1896; Langhoffer, 1904; D'Ancona, 1922; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Orepić *et al.*, 1997; Castellarin *et al.*, 2001; Novosel *et al.*, 2002; Herler *et al.*, 2005.

Gobius fallax: Kovačić, 1994, 1998; Jardas *et al.*, 1998.

Gobius xanthocephalus: Zavodnik & Kovačić, 2000; Kovačić, 2002b.

The species was first reported for the Adriatic Sea by Perugia (1866), without any notice on collection locality. The species was later listed for Venice, Trieste, the

Rijeka Bay, the Pašman Island, Zadar, the Zadar Channel, the Hvar Island, the Split area, Dalmatia, the Vis Island, and the Boka Kotorska Bay, without positive identification (Trois, 1875; Giglioli, 1880; Kolombatović, 1881, 1882, 1891; Perugia, 1881; A. P. Ninni, 1882; Faber, 1883; Vinciguerra, 1883; Damiani, 1896; Langhoffer, 1904; D'Ancona, 1922). The specimens from the Kvarner area, the central Adriatic, the Šolta Island, and Split are deposited in the collection of the Institute of Oceanography and Fisheries, Split, in the collection of the Natural History Museum Rijeka, and in the collection of Museo di Storia Naturale dell' Università di Firenze (Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, 1998, *unpubl. data*). The species belongs to *Gobius auratus* species complex (Miller & El-Tawil, 1974; Herler *et al.*, 2005) and specimens in the collections of Split and Firenze need re-examination because of morphological similarities between *G. auratus*, *G. fallax* and *G. xanthocephalus*. The specimens recorded in the Kvarner area as *G. fallax* in Kovačić (1994, 1998) and Jardas *et al.* (1998) belong to *G. auratus*. *G. xanthocephalus* reported in Zavodnik & Kovačić (2000) and Kovačić (2002b) for the Rijeka Bay is, according to Herler *et al.* (2005), north Adriatic color morph of *G. auratus*. Benthic biocoenological researches recorded the species in the Velebit Channel, and the Mljet Island (Orepić *et al.*, 1997; Novosel *et al.*, 2002), and the visual census researches recorded the species at Triest (Castellarin *et al.*, 2001), without positive identification. Herler *et al.* (2005) collected specimens at Selce, the Krk Island, the Cres Island (the Kvarner area), and the Murter Island (the central Adriatic Sea). The part of these specimens is deposited in the collection of the Naturhistorisches Museum Wien (Herler *et al.*, 2005).

***Gobius bucchichi* Steindachner, 1870**

Gobius Bucchichi: Steindachner, 1870.

Gobius buchichi: Perugia, 1881.

Gobius Buchichii: Kolombatović, 1881.

Gobius buchichii: A. P. Ninni, 1882.

Gobius bucchichi: Kolombatović, 1891; Tortonese, 1975; Onofri, 1983; Ahnelt, 1984; Zavodnik & Zavodnik, 1986; Mušin, 1989; Kraljević & Pallaoro, 1991; Kovačić, 1994, 1998, 2002b; Jardas *et al.*, 1996, 1998; Pallaoro & Jardas, 1996; Simonović *et al.*, 1996; Jaklin & Arko-Pijevac, 1997; Nocita & Vanni, 1997; Orepić *et al.*, 1997; De Girolamo *et al.*, 1998; Simonović, 1999; Guidetti & Bussotti, 2000; Zavodnik & Kovačić, 2000; Novosel *et al.*, 2002.

Gobius Bucchichii: Gridelli, 1931.

Gobius bucchichii: Guidetti, 2000; Castellarin *et al.*, 2001.

The species was described by Steindachner (1870) on the specimens collected at the Hvar Island. The syn-

types are deposited in the collection of the Museo Civico di Storia Naturale di Genova and in the collection of the Naturhistorisches Museum Wien (Tortonese, 1963; Miller, 1973a; Ahnelt, 1984). The species was listed for the Venice area, Trieste, the Rijeka Bay, Zadar, and the Split area (Kolombatović, 1881, 1891; A. P. Ninni, 1882; Perugia, 1881; Kovačić, 1994; Zavodnik & Kovačić, 2000). The specimens from Trieste, the Kvarner area, the Kornati Islands, the Biograd area, Split, the Šolta Channel, the Brač Channel, the Hvar Island, the Korčula Island, and Dubrovnik area are deposited in the collection of the Natural History Museum Rijeka, in the collection of the Institute of Oceanography and Fisheries, Split, in the collection of the Natural History Museum of Split, in the collection of the Natural History Museum of the Biological Institute, Dubrovnik, in the collection of the Museo Civico di Storia Naturale di Genova, in the collection of the Museo Civico di Storia Naturale di Trieste, in the collection of the Naturhistorisches Museum Wien, and in the collection of Museo di Storia Naturale dell'Università di Firenze (Gridelli, 1931; Tortonese, 1975; Onofri, 1983; Ahnelt, 1984; Mušin, 1989; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, 1998, *unpubl. data*). Specimens were collected by the small scale fishery gear at the Kornati Islands and the Murter Sea (Kraljević & Pallaoro, 1991; Jardas *et al.*, 1996). Benthic biocoenological researches recorded the species in the Raša Bay, the Lošinj Island, the Sv. Marko Islet, the Velebit Channel, the Kornati Islands, the Murter Sea, and the Mljet Island (Zavodnik & Zavodnik, 1986; Jardas *et al.*, 1996; Jaklin & Arko-Pijevac, 1997; Orepić *et al.*, 1997; Novosel *et al.*, 2002), and the visual census researches recorded the species in the Slovenian coastal waters, Trieste, the Rijeka Bay, Cavtat, the Tremiti Islands, and the Boka Kotorska Bay (Simonović *et al.*, 1996; De Girolamo *et al.*, 1998; Simonović, 1999; Guidetti, 2000; Guidetti & Bussotti, 2000; Castellarin *et al.*, 2001; Kovačić, 2002b; Jardas *et al.*, 1998).

***Gobius cobitis* Pallas, 1811**

Gobius capito: Perugia, 1866; Trois, 1875; Giglioli, 1880; Kolombatović, 1881, 1891; A. P. Ninni, 1882; Graeffe, 1888; Langhoffer, 1904; E. Ninni, 1912; D'Ancona, 1922.

Gobius exanthematosus: Perugia, 1881; Vinciguerra, 1883; Ušić, 2003.

Gobius cobitis: Cavinato, 1952; Marcuzzi, 1972; Tortonese, 1975; Mušin, 1989; Kovačić, 1994, 1998, 2002b; Jardas *et al.*, 1996; 1998; Pallaoro & Jardas, 1996; Caputo *et al.*, 1997; Nocita & Vanni, 1997; Orepić *et al.*, 1997; Caputo, 1998; De Girolamo *et al.*, 1998; Sorice & Caputo, 1999; Zavodnik & Kovačić, 2000; Castellarin *et al.*, 2001; Pallaoro, 2001; Novosel *et al.*, 2002; Turk *et al.*, 2002; Lipej *et al.*, 2003.

The species was first reported in the Adriatic Sea for Trieste (Perugia, 1866). The species was listed under various synonyms for Venice, the Venice Lagoon, Trieste, Istria, the Rijeka Bay, the Zadar Channel, the Murter Island, the Split area, the Hvar Island, the Vis Island, the Mljet Island, and Dalmatia (Trois, 1875; Giglioli, 1880; Kolombatović, 1881, 1891; A. P. Ninni, 1882; Perugia, 1881; Vinciguerra, 1883; Graeffe, 1888; Langhoffer, 1904; E. Ninni, 1912; D'Ancona, 1922; Cavinato, 1952; Kovačić, 1994; Zavodnik & Kovačić, 2000). The specimens from Venice, Trieste, the Istrian peninsula, the Kvarner area, the Pag Island, Dalmatia, the Split area, the central Adriatic, and the Dubrovnik area are deposited in the collection of the Center for Marine Research Rovinj, in the collection of the Natural History Museum Rijeka, in the collection of the Institute of Oceanography and Fisheries, Split, in the collection of Museo di Storia Naturale dell'Università di Firenze, in the collection of the Museo Civico di Storia Naturale di Genova, in the collection of l'Istituto di Idrobiologica di Chioggia, and in the collection of the Natural History Museum of the Biological Institute, Dubrovnik (Marcuzzi, 1972; Tortonese, 1975; Mušin, 1989; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, 1998, *unpubl. data*; Ušić, 2003; Zavodnik, *pers. comm.*). Specimens were collected by the small scale fishery gear in the Split area (Pallaoro, 2001). Benthic biocoenological researches recorded the species in the Velebit Channel, the Kornati Islands, the Murter Sea, and the Mljet Island (Jardas *et al.*, 1996; Orepić *et al.*, 1997; Novosel *et al.*, 2002), and the visual census researches recorded the species at Trieste, the Slovenian coastal waters, the Rijeka Bay, the Kornati Islands, and the Murter Sea (Jardas *et al.*, 1996; 1998; De Girolamo *et al.*, 1998; Castellarin *et al.*, 2001; Kovačić, 2002b; Turk *et al.*, 2002; Lipej *et al.*, 2003). The samples of *G. cobitis* were also collected at Ancona (Caputo *et al.*, 1997; Caputo, 1998; Sorice & Caputo, 1999).

***Gobius couchi* Miller & El-Tawil, 1974**

Gobius couchi: Kovačić, 2001a.

Fourteen females and fifteen males were collected for the first time in the Adriatic Sea at Oštro (the Kvarner area), in 1996 and 1997 (Kovačić, 2001a). The specimens are deposited in the collection of the Natural History Museum Rijeka. The additional findings in the Adriatic Sea are from Bakar, Klenovica, Kačjak (the Kvarner area), and the Šolta Island (the central Adriatic) (Kovačić, *unpubl. data*). These specimens are also deposited in the collection of the Natural History Museum Rijeka.

***Gobius cruentatus* Gmelin, 1789**

Gobius cruentatus: Nardo, 1827, 1860; Martens, 1838; Plućar, 1846; Perugia, 1866; Canestrini, 1872;

Trois, 1875; Giglioli, 1880; Kolombatović, 1881, 1891; A. P. Ninni, 1882; Vinciguerra, 1883; Graeffe, 1888; Langhoffer, 1904; D'Ancona, 1922; Županović, 1961; Marcuzzi, 1972; Tortonese, 1975; Jardas & Pallaoro, 1989; Cetinić & Pallaoro, 1990a, 1990b; Zavodnik & Crnković, 1992; Kovačić, 1994, 1998, 2002b, 2004; Jardas *et al.*, 1996, 1998; Pallaoro & Jardas, 1996; Simonović *et al.*, 1996; Nocita & Vanni, 1997; Orepić *et al.*, 1997; De Girolamo *et al.*, 1998; Simonović, 1999; Guidetti, 2000; Zavodnik & Kovačić, 2000; Arko Pijevac *et al.*, 2001; Castellarin *et al.*, 2001; Pallaoro, 2001; Novosel *et al.*, 2002; Turk *et al.*, 2002; Lipej *et al.* 2003; Usić, 2003.

The species was first reported in the Adriatic Sea for Venice (Nardo, 1827). The species was listed for the Venice Lagoon, Trieste, the Rijeka Bay, the Ugljan Island, the Split area, the Brač Island, the Šolta Island, the Lastovo Island, the Korčula Island, the Mljet Island, and the Vis Island (Martens, 1838; Plučar, 1846; Nardo, 1860; Perugia, 1866; Canestrini, 1872; Trois, 1875; Giglioli, 1880; A. P. Ninni, 1882; Vinciguerra, 1883; Graeffe, 1888; Kolombatović, 1881, 1891; Langhoffer, 1904; D'Ancona, 1922; Kovačić, 1994; Zavodnik & Kovačić, 2000). The specimens from Trieste, Rovinj, the Kvarner area, Zadar, the central Adriatic, Dalmatia, the Šolta Island, the Split area, and Dubrovnik are deposited in the collection of the Natural History Museum Rijeka, in the collection of the Institute of Oceanography and Fisheries, Split, in the collection of Istitituto di Idrobiologica di Chioggia, in the collection of the Museo Civico di Storia Naturale di Genova, and in the collection of Museo di Storia Naturale dell' Università di Firenze (Marcuzzi, 1972; Tortonese, 1975; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, 1998; Usić, 2003). The finding by the bottom trawl in the channels between the mid-Dalmatian islands (Županović, 1961) is quite surprising, considering depth and habitat preferences of the species. Specimens were collected by the small scale fishery gear at the Kornati Islands, the Murter Sea, the northern and the central Dalmatia, the Split area, the Split Channel, and the Brusnik Island (Jardas & Pallaoro, 1989; Cetinić & Pallaoro, 1990a, 1990b; Jardas *et al.*, 1996; Pallaoro, 2001). Benthic biocoenological researches recorded the species in the Kvarner area, the Velebit Channel, the Kornati Islands, the Murter Sea, and the Mljet Island (Zavodnik & Crnković, 1992; Jardas *et al.*, 1996; Orepić *et al.*, 1997; Arko Pijevac *et al.*, 2001; Novosel *et al.*, 2002), and the visual census researches recorded the species at Trieste, the Slovenian coastal waters, the Rijeka Bay, and the Tremiti Islands (De Girolamo *et al.*, 1998; Jardas *et al.*, 1998; Guidetti, 2000; Castellarin *et al.*, 2001; Kovačić, 2002b; Turk *et al.*, 2002; Lipej *et al.* 2003). The samples of this species were also collected in the Kvarner area and the Boka Kotorska Bay (Simonović *et al.*, 1996; Simonović, 1999; Kovačić, 2004).

***Gobius fallax* Sarato, 1889**

Gobius fallax: Gridelli, 1931; E. Ninni, 1938; Tortonese, 1975; Ahnelt, 1984; Cetinić & Pallaoro, 1990b; Jardas *et al.*, 1996; Pallaoro & Jardas, 1996; De Girolamo *et al.*, 1998; Zavodnik & Kovačić, 2000; Turk *et al.*, 2002; Lipej *et al.* 2003; Herler *et al.*, 2005.

The species was first reported in the Adriatic Sea for Trieste and Šibenik (Gridelli, 1931). Miller (1973a) supposed that *G. auratus* v. *ruginosa* of Kolombatović (1891) from the Split area is a synonym of *G. fallax*. The species was listed for Venice and the Korčula Island (E. Ninni, 1938; Tortonese, 1975). Single specimen, among Steindacher's syntypes of *G. bucchichi* from 1870, were found in the collection of the Naturhistorisches Museum Wien and identified by Ahnelt (1984). The specimens from Trieste, the Goli Island in the Kvarner area, Šibenik, and the Šolta Island are deposited in the collection of the Natural History Museum Rijeka, in the collection of the Museo Civico di Storia Naturale di Trieste, and in the collection of the Institute of Oceanography and Fisheries, Split (Gridelli, 1931; Pallaoro & Jardas, 1996; Zavodnik & Kovačić, 2000; Kovačić, *unpubl. data*). The species belongs to *Gobius auratus* species complex (Miller & El-Tawil, 1974; Herler *et al.*, 2005) and specimens in the collections in Trieste and Split need re-examination considering morphological similarities between *G. auratus*, *G. fallax* and *G. xanthocephalus*. Specimens collected by the small scale fishery gear at the Kornati Islands and the Murter Sea, the northern and the central Dalmatia (Cetinić & Pallaoro, 1990b; Jardas *et al.*, 1996) were not positively identified. Benthic biocoenological researches recorded the species at the Kornati Islands and the Murter Sea (Jardas *et al.*, 1996), and the visual census researches recorded the species at Trieste and the Slovenian coastal waters, (De Girolamo *et al.*, 1998; Turk *et al.*, 2002; Lipej *et al.* 2003), without positive identification. The specimens recorded in Kovačić (1994, 1998) and Jardas *et al.* (1998) as *G. fallax*, belong to another gobiid species, *G. auratus*. Herler *et al.* (2005) collected specimens at Trieste, Piran, the Cres Island and the Šolta Island. The part of these specimens is deposited in the collection of Naturhistorisches Museum Wien.

***Gobius geniporus* Valenciennes, 1837**

Gobius geniporus: Perugia, 1866; Giglioli, 1880; Kolombatović, 1881, 1891; Faber, 1883; Vinciguerra, 1883; Marcuzzi, 1972; Tortonese, 1975; Cetinić & Pallaoro, 1990a, 1990b; Ahnelt & Elvira, 1991; Kraljević & Pallaoro, 1991; Kovačić, 1994, 1998, 2002b; Jardas *et al.*, 1996, 1998; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Guidetti, 2000; Zavod-

nik & Kovačić, 2000; Arko Piševac *et al.*, 2001; Pallaoro, 2001; Lipej *et al.* 2003; Ušić, 2003.

The species was first reported in the Adriatic Sea for Trieste (Perugia, 1866). The species was listed for Venice, Ravenna, Trieste, the Rijeka Bay, Dalmatia, the Split area, the Mljet Island, the Lastovo Island, the Korčula Island, and the Boka Kotorska Bay (Giglioli, 1880; Kolombatović, 1881, 1891; Faber, 1883; Vinciguerra, 1883; Kovačić, 1994; Zavodnik & Kovačić, 2000). The specimens from Trieste, Rovinj, the Kvarner area, the central Adriatic, Dalmatia, Dubrovnik and Kotor are deposited in the collection of the Center for Marine Research of the Ruđer Bošković Institute in Rovinj, in the collection of the Natural History Museum Rijeka, in the collection of the Institute of Oceanography and Fisheries, Split, in the collection of Museo di Storia Naturale dell'Università di Firenze, in the collection of the Museo Civico di Storia Naturale di Genova, in the collection of l'Istituto di Idrobiologica di Chioggia, and in the collection of the Naturhistorisches Museum Wien (Marcuzzi, 1972; Tortonese, 1975; Ahnelt & Elvira, 1991; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, 1998, *unpubl. data*; Ušić, 2003). Specimens were collected by the small scale fishery gear at the Kornati Islands, the Murter Sea, the northern and the central Dalmatia, the Split area, and the Split Channel (Cetinić & Pallaoro, 1990a, 1990b; Kraljević & Pallaoro, 1991; Jardas *et al.*, 1996; Pallaoro, 2001). Benthic biocoenological researches recorded the species in the Kvarner area, at the Kornati Islands, and the Murter Sea (Jardas *et al.*, 1996; Arko Piševac *et al.*, 2001), and the visual census researches recorded the species in the Slovenian coastal waters, the Rijeka Bay, and the Tremiti Islands (Jardas *et al.*, 1998; Guidetti, 2000; Kovačić, 2002b; Lipej *et al.* 2003).

***Gobius kolombatovici* Kovačić & Miller, 2000**

Gobius kolombatovici: Kovačić & Miller, 2000.

The species was described by Kovačić & Miller (2000) on four females and six males collected at four closely situated localities at the Krk Island (the Kvarner area), in June and September of 1998. The holotype and paratypes are deposited in the collection of the Natural History Museum Rijeka. Single paratype was donated to the British Museum of Natural History. Single additional female in the Adriatic Sea was collected at the Čutina Island, near the Cres Island, the Kvarner area (Kovačić, *unpubl. data*). It is also deposited in the collection of the Natural History Museum Rijeka.

***Gobius niger* Linnaeus, 1758**

Gobius jozo: Brünnich, 1765; Plućar, 1846; Perugia, 1866, 1881; Giglioli, 1880; Kolombatović, 1881,

1891; A. P. Ninni, 1882; Vinciguerra, 1883; Graeffe, 1888; Langhoffer, 1904; D'Ancona, 1922; Zei, 1942, 1949; Zavodnik, 1971; Marcuzzi, 1972.

Gobius Jozo: Nardo, 1827; Martens, 1838.

Gobius niger: Naccari, 1822; Nardo, 1827; Martens, 1838; Plućar, 1846; Perugia, 1866, 1881; Giglioli, 1880; A. P. Ninni, 1882; Graeffe, 1888; D'Ancona, 1922; Zei, 1942, 1949; Cavinato, 1952; Županović, 1961; Tortonese, 1975; Jukić & Piccinetti, 1981; Fabi & Froglija, 1983, 1984; Jukić, 1983; Onofri, 1983; Fabi & Giannetti, 1985; Zavodnik & Zavodnik, 1986; Jardas & Pallaoro, 1989; Seiwald & Patzner, 1989; Cetinić & Pallaoro, 1990b; Zavodnik & Crnković, 1992; Kovačić, 1994, 1998; Jardas *et al.*, 1996, 1998; Marconato *et al.*, 1996; Pallaoro & Jardas, 1996; Simonović *et al.*, 1996; Špan *et al.*, 1996; Caputo *et al.*, 1997; McKay & Miller, 1997; Nocita & Vanni, 1997; Orepić *et al.*, 1997; Atkinson *et al.*, 1998; Caputo, 1998; Simonović, 1999; Sorice & Caputo, 1999; Zavodnik & Kovačić, 2000; Pallaoro, 2001; Mazzoldi & Rasotto, 2002; Novosel *et al.*, 2002; Rasotto & Mazzoldi, 2002; Turk *et al.*, 2002; Lipej *et al.* 2003; Ušić, 2003.

Gobius jozo var. *nigra*: Nardo, 1860.

Gobius jorzo: Trois, 1875.

Gobius niger jozo: Jukić & Crnković, 1974; Jukić, 1975.

Gobius jozzo: Ušić, 2003.

The species was first reported in the Adriatic Sea for the Split and trogir areas (Brünnich, 1765). The species was listed for Venice, the Venice Lagoon, Trieste, the Rijeka Bay, the Kvarner area, Ravenna, the Zadar Channel, the Split area, Dalmatia, the Hvar Island, the Korčula Island, the Lastovo Island, and the Boka Kotorska Bay (Naccari, 1822; Nardo, 1827, 1860; Martens, 1838; Plućar, 1846; Perugia, 1866, 1881; Trois, 1875; Giglioli, 1880; Kolombatović, 1881, 1891; A. P. Ninni, 1882; Vinciguerra, 1883; Graeffe, 1888; Langhoffer, 1904; D'Ancona, 1922; Cavinato, 1952; Kovačić, 1994; Zavodnik & Kovačić, 2000). The specimens from Venice, Trieste, Ravenna, Civitanova Marche, near Rovinj, the Kvarner area, the Pag Island, the Zadar Channel, the Murter Island, the Šibenik area, the Šolta Island, the Hvar Island, the Hvar Channel, the Split area, the Mljet Island, the Neretva Channel, and Dubrovnik are deposited in the collection of the Center for Marine Research of the Ruđer Bošković Institute in Rovinj, in the of the Natural History Museum Rijeka, in the collection of the Institute of Oceanography and Fisheries, Split, in the collection of the Natural History Museum of Split, in the collection of the Museo Civico di Storia Naturale di Genova, in the collection of l'Istituto di Idrobiologica di Chioggia, and in the collection of Museo di Storia Naturale dell'Università di Firenze (Marcuzzi, 1972; Tortonese, 1975; Onofri, 1983; Pallaoro & Jardas, 1996;

Nocita & Vanni, 1997; Kovačić, 1998, *unpubl. data*; Ušić, 2003). Specimens were collected by the small scale fishery gear at the Kornati Islands and Murter Sea, the northern and the central Dalmatia, the Split area, and the Kaštela Bay (Jardas & Pallaoro, 1989; Cetinić & Pallaoro, 1990b; Jardas *et al.*, 1996; Pallaoro, 2001), and by the bottom trawl in the northern Adriatic, the channels of the north-eastern Adriatic Sea, the central Adriatic, the channels between the mid-Dalmatian islands, the Crnogorsko primorje (Zei, 1942, 1949; Županović, 1961; Jukić & Crnković, 1974; Jukić, 1975; Jukić & Piccinetti, 1981; Jukić, 1983; Špan *et al.*, 1996). Benthic biocoenological researches recorded the species in the Rovinj area, the Raša Bay, the Lošinj Island, the Velebit Channel, the Kornati Islands, the Murter Sea, and the Mljet Island (Zavodnik, 1971; Zavodnik & Zavodnik, 1986; Zavodnik & Crnković, 1992; Jardas *et al.*, 1996; Orepić *et al.*, 1997; Novosel *et al.*, 2002) and the visual census researches recorded the species in the Slovenian coastal waters and the Rijeka Bay (Jardas *et al.*, 1998; Turk *et al.*, 2002; Lipej *et al.* 2003). The samples of *G. niger* were also collected in the Venice Lagoon, Aurisina, Ancona, and the Boka Kotorska Bay (Fabi & Froglija, 1983, 1984; Fabi & Giannetti, 1985; Seiwald & Patzner, 1989; Marconato *et al.*, 1996; Simonović *et al.*, 1996; Caputo *et al.*, 1997; McKay & Miller, 1997; Atkinson *et al.*, 1998; Caputo, 1998; Simonović, 1999; Sorice & Caputo, 1999; Mazzoldi & Rasotto, 2002; Rasotto & Mazzoldi, 2002).

***Gobius paganellus* Linnaeus, 1758**

Gobius Paganellus: Naccari, 1822; Nardo, 1827; Martens, 1838.

Gobius paganellus: Plućar, 1846; Nardo, 1860; Perugia, 1866, 1881; Canestrini, 1872; Trois, 1875; Giglioli, 1880; Kolombatović, 1881, 1891; Perugia, 1881; A. P. Ninni, 1882; Graeffe, 1888; Langhoffer, 1904; E. Ninni, 1912; D'Ancona, 1922; Zei, 1942, 1949; Cavinato, 1952; Mušin, 1989; Cetinić & Pallaoro, 1990a; Jardas *et al.*, 1996; Pallaoro & Jardas, 1996; Simonović *et al.*, 1996; Caputo *et al.*, 1997; Nocita & Vanni, 1997; Orepić *et al.*, 1997; Caputo, 1998; De Girolamo *et al.*, 1998; Kovačić, 1998, 2002b; Simonović, 1999; Sorice & Caputo, 1999; Zavodnik & Kovačić, 2000; Castellarin *et al.*, 2001; Turk *et al.*, 2002; Lipej *et al.* 2003; Ušić, 2003.

The species was first reported in the Adriatic Sea for Venice (Naccari, 1822). The species was listed for the Venice Lagoon, Trieste, Rijeka, the Ugljan Island, the Split area, and Dalmatia (Nardo, 1827; Martens, 1838; Plućar, 1846; Nardo, 1860; Perugia, 1866, 1881; Canestrini, 1872; Trois, 1875; Giglioli, 1880; Kolombatović, 1881, 1891; A. P. Ninni, 1882; Graeffe, 1888; Langhoffer, 1904; E. Ninni, 1912; D'Ancona, 1922; Cavinato, 1952;

Zavodnik & Kovačić, 2000). The specimens from Chioggia, Trieste, Civitanova Marche, Rovinj, the Pag Island, the Split area, the mouth of the Neretva river, and the Dubrovnik area are deposited in the collection of the Museo Zoologico di Padova, in the collection of l'Istituto di Idrobiologica di Chioggia, in the collection of the Natural History Museum Rijeka, in the collection of the Institute of Oceanography and Fisheries, Split, in the collection of the Natural History Museum of the Biological Institute, Dubrovnik, and in the collection of Museo di Storia Naturale dell'Università di Firenze (Mušin, 1989; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, 1998, *unpubl. data*; Ušić, 2003). The finding by the bottom trawl in the northern Adriatic (Zei, 1942, 1949) is quite surprising, considering depth and habitat preferences of the species. Specimens were collected by the small scale fishery gear at the Kornati Islands, the Murter Sea, and the Split Channel (Cetinić & Pallaoro, 1990a; Jardas *et al.*, 1996). Benthic biocoenological researches recorded the species at the Kornati Islands, the Murter Sea, and the Mljet Island (Jardas *et al.*, 1996; Orepić *et al.*, 1997) and the visual census researches recorded the species at Trieste, the Slovenian coastal waters and Kostrena (De Girolamo *et al.*, 1998; Castellarin *et al.*, 2001; Kovačić, 2002b; Turk *et al.*, 2002; Lipej *et al.* 2003). The samples of *G. paganellus* were also collected at Ancona, Buljarica and the Boka Kotorska Bay (Simonović *et al.*, 1996; Caputo *et al.*, 1997; Caputo, 1998; Simonović, 1999; Sorice & Caputo, 1999).

***Gobius roulei* De Buen, 1928**

Gobius roulei: Kovačić, 1995, 2001b, 2002b; Jardas *et al.*, 1996, 1998; Pallaoro & Jardas, 1996; Zavodnik & Kovačić, 2000; Turk *et al.*, 2002; Lipej *et al.*, 2003; Ušić, 2003.

Single female and seven males were collected for the first time in the Adriatic Sea at four localities in the Kvarner area in 1993 and 1994 (Kovačić, 1995). The specimens are deposited in the collection of the Natural History Museum Rijeka. The additional specimens in the Kvarner area were collected by Kovačić (2001b). The species was also recorded at numerous localities in the Kvarner area (Kovačić, 1995; Zavodnik & Kovačić, 2000). The additional findings in the Adriatic Sea are from the Gulf of Trieste (the northern Adriatic) (Lipej *et al.*, 2003), the Pag Island, the Kornati Islands, and the Murter Sea (the central Adriatic) (Jardas *et al.*, 1996; Pallaoro & Jardas, 1996). The specimens from the Pag Island and from the Rijeka Bay are deposited in the collection of the Institute of Oceanography and Fisheries, Split and in the collection of the Center for Marine Research of the Ruđer Bošković Institute in Rovinj. Specimens were collected by the small scale fishery gear at the Kornati Islands and the Murter Sea (Jardas *et al.*,

1996). Benthic biocoenological researches recorded the species at the Kornati Islands and the Murter Sea (Jardas *et al.*, 1996), and the visual census researches recorded the species in the Slovenian coastal waters and the Rijeka Bay (Jardas *et al.*, 1998; Kovačić, 2002b; Turk *et al.*, 2002; Lipej *et al.* 2003).

***Gobius vittatus* Vinciguerra, 1883**

Gobius vittatus: Kolombatović, 1886, 1891; Kovačić, 1994, 1998, 2002b; Pallaoro & Jardas, 1996; Jardas *et al.*, 1996; Nocita & Vanni, 1997; Jardas *et al.*, 1998; Zavodnik & Kovačić, 2000; Novosel *et al.*, 2002.

Two specimens were collected for the first time in the Adriatic Sea near Split in 1884 (Kolombatović, 1886). The additional collected specimen and details on time and locality of collecting of the first two specimens was published later (Kolombatović, 1891). The species was reported for the Rijeka Bay (Kovačić, 1994; Zavodnik & Kovačić, 2000). The specimens from the Kvarner area and Split are deposited in the collection of the Natural History Museum Rijeka, in the collection of the Institute of Oceanography and Fisheries, Split, and in the collection of Museo di Storia Naturale dell' Università di Firenze (Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, 1998, *unpubl. data*). Specimens were collected by the small scale fishery gear at the Kornati Islands and the Murter Sea (Jardas *et al.*, 1996). Benthic biocoenological researches recorded the species at the Velebit Channel, the Kornati Islands, and the Murter Sea (Jardas *et al.*, 1996; Novosel *et al.*, 2002) and the visual census researches recorded the species in the Rijeka Bay (Jardas *et al.*, 1998; Kovačić, 2002b).

***Knipowitschia caucasica* (Kawrajsky, 1916)**

Knipowitschia caucasica: Miller, 1972c; Pallaoro & Jardas, 1996; Kovačić & Pallaoro, 2003.

Two females, collected at Zaule (near Trieste), were found in the collection of the Museo Civico di Storia Naturale di Venice and identified by Miller (1972c). Additional male was collected from the Venice Lagoon by H. Bath (Miller, 1972c). Econodimis and Miller (1990) believed that Adriatic population was "a *caucasica*-like form, which differs from true *caucasica* in body proportions, and may represent a new, unnamed species". Kovačić & Pallaoro (2003) confirmed previously questioned presence of this species in the Adriatic Sea and provide data on morphology and ecology of the Adriatic specimens. The specimens from the northern and central Dalmatia, Croatia: the Pag Island, the river Karišnica, the Karin Sea, the Vrana Lake, Pirovac, the mouth of the river Jadro, in the Morinj Bay, the Prokljan Lake, the spring and the mouth of the river Pantan in the Kaštela

Bay, and the river Cetina are deposited in the collection of the Natural History Museum Rijeka (Kovačić & Pallaoro, 2003). The specimens from the Prokljan Lake are deposited in the collection of the Institute of Oceanography and Fisheries, Split (Pallaoro & Jardas, 1996).

***Knipowitschia panizzae* (Verga, 1841)**

Gobius Panizzae: Verga, 1841; Trois, 1875; Giglioli, 1880; E. Ninni, 1912.

Gobius panizzae: Nardo, 1860; A. P. Ninni, 1882.

Gobius Panizzai: E. Ninni, 1938.

Pomatoschistus panizzai: Bini, 1969.

Knipowitschia panizzai: Tortonese, 1975; Gandolfi & Tongiorgi, 1976; Nocita & Vanni, 1997.

Knipowitschia panizzae: Gandolfi, 1972; Miller, 1972c; Marconato *et al.*, 1996; Pallaoro & Jardas, 1996; McKay & Miller, 1997; Lugli & Torricelli, 1999; Marzano & Gandolfi, 2000, 2001.

The species was described by Verga (1841) on the specimens collected at the Lago di Comacchio. The species was listed for Laguna di Venice, the Sile river, the Piave river, the Livenza river, the Po river, the rivers of Veneto, Porto Tolle, Lago di Comacchio, the river Fortore, and Laguna di Lesina (Nardo, 1860; Trois, 1875; Giglioli, 1880; A. P. Ninni, 1882; E. Ninni, 1912, 1938; Bini, 1969; Gandolfi, 1972; Miller, 1972c; Gandolfi & Tongiorgi, 1976), without positive identification. The findings at the Lago di Garda and the Krk Island were considered as erroneous (Miller, 1972c). The samples of this species were also collected in the Po delta and the Venice Lagoon, without positive identification (Gandolfi, 1972; Marconato *et al.*, 1996; McKay & Miller, 1997; Lugli & Torricelli, 1999; Marzano & Gandolfi, 2001). The specimens from the mouth of the river Po, Caorle (Veneto), the Venice Lagoon, Trieste, Civitanova Marche, and the Vrana Lake are deposited in the collection of the Museo Civico di Storia Naturale di Genova, in the collection of the Institute of Oceanography and Fisheries, Split, and in the collection of Museo di Storia Naturale dell' Università di Firenze (Tortonese, 1975; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997). All these specimens should be reexamined considering morphological similarities between *K. panizzae* and *K. caucasica* (Kovačić & Pallaoro, 2003).

***Lebetus guiletti* (Le Danois, 1913)**

Lebetus guiletti: Herler & Kovačić, 2002.

Eight females and five males were collected for the first time in the Adriatic Sea at Selce and Klenovica (the Kvarner area) in 1999 and 2001 (Herler & Kovačić, 2002). The specimens are deposited in the collection of the Naturhistorisches Museum Wien and in the collec-

tion of the Natural History Museum Rijeka. The additional finding is documented photographically at the western coast of Istria, near Rovinj in May 2002 (Herler & Kovačić, 2002).

***Lesueurigobius friesii* (Malm, 1874)**

Gobius friesii-macrolepis: Šoljan, 1948; Županović & Grubišić, 1958; Županović, 1961.

Lesueurigobius friesii: Jukić & Crnković, 1974; Jukić, 1975; Jardas *et al.*, 1981, 1996, 1998; Froglija & Gramitto, 1982; Jukić, 1983; Zavodnik & Zavodnik, 1986; Županović & Jardas, 1989; Jardas, 1996b; Pallaoro & Jardas, 1996; Kovačić, 1998; Zavodnik & Kovačić, 2000; Usić, 2003.

The first positive record of this species in the Adriatic Sea was based on specimens collected at the Krk Island by the bottom trawl in 1940 (Šoljan, 1948). The specimens collected near Rovinj, at the Raša Bay, the Kvarner area, the Šolta Channel, NW from the Islet of Jabuka, the Brač Island and at Budva are deposited in the collection of the Center for Marine Research of the Ruđer Bošković Institute Rovinj, in the collection of the Natural History Museum Rijeka, and in the collection of the Institute of Oceanography and Fisheries, Split (Pallaoro & Jardas, 1996; Kovačić, 1998, *unpubl. data*; Usić, 2003). Specimens were collected by the small scale fishery gear at the Kornati Islands and the Murter Sea (Jardas *et al.*, 1996) and by the bottom trawl in the Kvarner area, the Rijeka Bay, south of Rogoznica, at the Jabuka Pit, the Palagruža Island, the central Adriatic, the channels between the mid-Dalmatian islands and at Crnogorsko primorje (Županović & Grubišić, 1958; Županović, 1961; Jukić & Crnković, 1974; Jukić, 1975, 1983; Jardas *et al.*, 1981, 1998; Froglija & Gramitto, 1982; Županović & Jardas, 1989; Zavodnik & Kovačić, 2000). Benthic biocoenological researches recorded the species at the Raša Bay, and in the Murter Sea (Zavodnik & Zavodnik, 1986; Jardas, 1996b).

***Lesueurigobius suerii* (Risso, 1810)**

Gobius Lunieus: Chiareghini, 1818.

Gobius lunie: Nardo, 1827.

Gobius luniè: Nardo, 1860.

Gobius Lesueuri: Kolombatović, 1881.

Gobius lesueuri: Kolombatović, 1882, 1891; Županović, 1961; Crnković, 1970; Zavodnik, 1971; Jukić & Crnković, 1974.

Gobius Lesueurii: Vinciguerra, 1883; Langhoffer, 1904.

Gobius lesueurii: A. P. Ninni, 1882; E. Ninni, 1912.

Lesueurigobius suerii: Zavodnik & Crnković, 1992; Jardas *et al.*, 1996, 1998; Usić, 2003; Ahnelt & Dorda, 2004.

Lesueurigobius sueri: Tortonese, 1975; Nocita & Vanni, 1997; Sorice & Caputo, 1999.

The species was recorded for the first time in the Adriatic Sea for the Venice Lagoon (Chiareghini, 1818, cited in Ninni, 1938). The species was listed under various synonyms for the Venice Lagoon, the Zadar Channel, the Split area, and the Boka Kotorska Bay (Nardo, 1827, 1860; Kolombatović, 1881, 1882, 1891; A. P. Ninni, 1882; Vinciguerra, 1883; Langhoffer, 1904; E. Ninni, 1912). The specimens collected near Rovinj, from Dalmatia, the Sv. Andrija Island, and Bari are deposited in the collection of the Center for Marine Research of the Ruđer Bošković Institute in Rovinj, in the collection of the Naturhistorisches Museum Wien, in the collection of the Museo Civico di Storia Naturale di Genova, and in the collection of Museo di Storia Naturale dell'Università di Firenze (Tortonese, 1975; Nocita & Vanni, 1997; Usić, 2003; Ahnelt & Dorda, 2004; Zavodnik, *pers. comm.*). Specimens were collected by the small scale fishery gear at the Kornati Islands and the Murter Sea (Jardas *et al.*, 1996) and by the bottom trawl in the channels of the north-eastern Adriatic Sea, near Rogoznica, the channels between the mid-Dalmatian islands, and Crnogorsko primorje (Županović, 1961; Crnković, 1970; Jukić & Crnković, 1974). Benthic biocoenological researches recorded the species at Rovinj and in the Kvarner area (Zavodnik, 1971; Jardas *et al.*, 1998; Zavodnik & Crnković, 1992). The samples of this species were also collected at Ancona (Sorice & Caputo, 1999).

***Millerigobius macrocephalus* (Kolombatović, 1891)**

Gobius macrocephalus: Kolombatović, 1891.

Millerigobius macrocephalus: Bath, 1973; Turk *et al.*, 2002; Lipej *et al.* 2003.

The species was described by Kolombatović (1891) on single specimen collected at the Brač Island (the central Adriatic) in 1887. Bath (1973) redescribed the species on four males collected at Medulin and the Limski Channel in Istria, in July 1972. The neotypes are deposited in the collection of the Senckenberg Naturmuseum, Frankfurt. The additional specimens in the Adriatic Sea were collected at the Šolta Island, the central Adriatic (Kovačić, *unpubl. data*). They are deposited in the collection of the Natural History Museum Rijeka. Visual census research recorded the species in the Slovenian coastal waters (Turk *et al.*, 2002; Lipej *et al.* 2003).

***Odontobuenia balearica* (Pellegrin & Fage, 1907)**

Gobius liechtensteini: Kolombatović, 1891 (*part.*).

Odontobuenia balearica: Miller & Tortonese, 1968;

Ahnelt *et al.*, 1994; Jardas *et al.*, 1996; Pallaoro & Jardas, 1996.

Single specimen collected at Split and four specimens collected at the Korčula Island (the central Adriatic) were found and identified by Miller & Tortonese (1968) in the collection of the Museo Zoologico, Università di Firenze and in the collection of the Naturhistorisches Museum Wien. The additional specimens in the Adriatic Sea were collected at Rovinj (the Istrian peninsula); Urinj, Bakar, Oštro, Klenovica, the Krk Island, the Ćutin Island (the Kvarner area); Split, Stobreč, the Šolta Island, the Hvar Island, Mala Duba, the Biševo Island, and the Palagruža Island (the central Adriatic); Mljet (the southern Adriatic) (Ahnelt *et al.*, 1994; Pallaoro & Jardas, 1996; Kovačić, *unpubl. data*). They are deposited in the collection of the Natural History Museum Rijeka, in the collection of the Institute of Oceanography and Fisheries, Split and in the collection of the Naturhistorisches Museum Wien. The species was recorded in benthic biocoenological research at the Kornati Islands (the central Adriatic) (Jardas *et al.*, 1996).

***Pomatoschistus bathi* Miller, 1982**

Pomatoschistus bathi: Miller, 1982; Ahnelt *et al.*, 1994; Pallaoro & Jardas, 1996; Lipej *et al.*, 2003.

Single male and twelve females from the private collection of H. Bath were identified by Miller (1982). The specimens were collected in the Bay of Kotor (the southern Adriatic) on May 10 1969. The additional Adriatic specimens were collected at the Krk Island, the Ćutin Island, the Lošinj Island (the Kvarner area); Seline (the Velebit Channel); the mouth of the river Zrmanja, the Prokljan Lake, the Murter Island, the Morinje Cove, the Brač Island, Blace (the central Adriatic); the Mljet Island (the southern Adriatic) (Ahnelt *et al.*, 1994; Pallaoro & Jardas, 1996; Kovačić, *unpubl. data*). They are deposited in the collection of the Natural History Museum Rijeka and in the collection of the Institute of Oceanography and Fisheries, Split. Visual census researches recorded the species in the Slovenian coastal waters (the northern Adriatic) (Lipej *et al.*, 2003).

***Pomatoschistus canestrinii* (Ninni, 1883)**

Gobius quagga: Kolombatović, 1881.

Gobius Canestrinii: A. P. Ninni, 1883.

Gobius Canestrini: Kolombatović, 1888; E. Ninni, 1938.

Gobius canestrini: Kolombatović, 1891; Cavinato, 1952.

Pomatoschistus canestrini: Bini, 1969; Tortonese, 1975; Mrakovčić *et al.*, 1994; Lugli & Torricelli, 1999.

Pomatoschistus canestrinii: Gandolfi *et al.*, 1982; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; McKay & Miller, 1997.

The species was described by A. P. Ninni (1883) on the specimens collected by Kolombatović at the Jadro river. The species was mentioned from the type locality earlier, as a form of *Gobius quagga*, also by Kolombatović (1881). The additional collected specimens were studied for the Split area by Kolombatović (1888, 1891). The species was listed for the Venice Lagoon, Piave river and Livenza river (E. Ninni, 1938; Cavinato, 1952; Bini, 1969). The specimens from the Venice Lagoon, Trieste, the Zrmanja river and its tributary Dobarnica, the Krka river, the Jadro river, the Žrnovnica river, the Cetina river, the Bačina Lakes, and the Neretva river are deposited in the collection of the Natural History Museum Rijeka, in the collection of the Museo Civico di Storia Naturale di Genova, in the collection of the Institute of Oceanography and Fisheries, Split, and in the collection of Museo di Storia Naturale dell'Università di Firenze (Tortonese, 1975; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, *unpubl. data*). The samples of this species were also collected at the mouth of the Tagliamento river, the mouth of the Stella river, the mouth of the Livenza river, the mouth of the Dese river, the Laguna del Basson, the Venice Lagoon, the mouth of river Po, and in the Zrmanja river (Gandolfi *et al.*, 1982; Mrakovčić *et al.*, 1994; McKay & Miller, 1997; Lugli & Torricelli, 1999).

***Pomatoschistus knerii* (Steindachner, 1861)**

Gobius Knerii: Steindachner, 1861; Langhoffer, 1904.

Gobius Kneri: Giglioli, 1880.

Gobius knerii: Kolombatović 1893.

Gobius steindachnerii: Kolombatović 1900.

Pomatoschistus knerii: Jardas *et al.*, 1996, 1998; Kovačić, 1998, 2003; Zavodnik & Kovačić, 2000.

The species was described by Steindachner (1861) on the specimens collected at the Hvar Island. The additional specimens were reported at Venice, Zaola (near Trieste), the Kornati Islands, and at Seget (near Split) (Giglioli, 1880; Kolombatović 1893, 1900; A. P. Ninni, 1882; Langhoffer, 1904). The specimens from the Kvarner area and the Žakan Island are deposited in the collection of the Natural History Museum Rijeka (Jardas *et al.*, 1998; Kovačić, 1998, 2003, *unpubl. data*; Zavodnik & Kovačić, 2000). Specimens were collected by the small scale fishery gear at the Kornati Islands and in the Murter Sea (Jardas *et al.*, 1996).

***Pomatoschistus marmoratus* (Risso, 1810)**

Gobius ferrugineus: Kolombatović, 1891.

Gobius marmoratus: Ninni, 1938; Cavinato, 1952.

Pomatoschistus marmoratus: Bini, 1969; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Caputo, 1998; Kovačić, 1998; Lugli & Torricelli, 1999; Mazzoldi & Rasotto, 2001; Mazzoldi *et al.*, 2002; Turk *et al.*, 2002; Lipej *et al.* 2003; Usić, 2003.

The species was first reported in the Adriatic Sea for the Split area under the synonym *Gobius ferrugineus* (Kolombatović, 1891). The species was listed for Venice (E. Ninni, 1938; Cavinato, 1952; Bini, 1969). The specimens from Chioggia, the Venice Lagoon, the Triest area, the Kvarner area, the Pag Island, the Zrmanja river, the Karin Sea, the Zadar area, the Žakan Island, the Biograd area, the Šibenik area, the Trogir area, the mouth of the river Žrnovnica, Omiš, the Ombla river, and Bari are deposited in the collection of the Museo Zoologico di Padova, in the collection of the Natural History Museum Rijeka, in the collection of the Institute of Oceanography and Fisheries, Split, and in the collection of Museo di Storia Naturale dell' Università di Firenze (Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, 1998, *unpubl. data*). Visual census researches recorded the species in the Slovenian coastal waters (Turk *et al.*, 2002; Lipej *et al.* 2003). The samples of this species were also collected in the Po delta, in the Venice Lagoon, and at Ancona (Caputo, 1998; Lugli & Torricelli, 1999; Mazzoldi & Rasotto, 2001; Mazzoldi *et al.*, 2002; Usić, 2003).

***Pomatoschistus minutus* (Pallas, 1770)**

Gobius minutus: Plućar, 1846; Perugia, 1866, 1881; Trois, 1875; Giglioli, 1880; Kolombatović, 1881; Graeffe, 1888; E. Ninni, 1938; Cavinato, 1952; Marcuzzi, 1972; Gamulin-Brida *et al.*, 1980.

Gobius minutus elongatus: Županović, 1961.

Pomatoschistus minutus: Nocita & Vanni, 1997; Caputo, 1998; Sorice & Caputo, 1999; Stefanni *et al.*, 2003; Usić, 2003.

The species was recorded for the first time in the Adriatic Sea for the Triest area (Plućar, 1846). The species was listed for Venice, Triest, and the Split area (Perugia, 1866, 1881; Trois, 1875; Giglioli, 1880; Kolombatović, 1881, 1891; Graeffe, 1888; E. Ninni, 1938; Cavinato, 1952). The specimens from the Venice Lagoon, the Triest area, the Kvarner area, the mouth of the river Zrmanja and the mouth of the river Neretva are deposited in the collection of Museo di Storia Naturale dell' Università di Firenze, in the collection of l'Istituto di Idrobiologica di Chioggia, and in the collection of the Natural History Museum Rijeka (Marcuzzi, 1972; Nocita

& Vanni, 1997; Kovačić, *unpubl. data*; Usić, 2003). Specimens were collected by the bottom trawl between the mid-Dalmatian islands (Županović, 1961), without a positive identification. Benthic biocoenological research recorded the species at the Krk Island (Gamulin-Brida *et al.*, 1980), without positive identification. The samples of this species were recently collected at Venice and Ancona (Caputo, 1998; Sorice & Caputo, 1999; Stefanni *et al.*, 2003).

***Pomatoschistus norvegicus adriaticus* (Miller, 1972)**

Pomatoschistus norvegicus: Stefanni, 2000.

Four females and a single male were collected for the first time in the Adriatic Sea of the littoral of Venice in March 1998 (Stefanni, 2000).

***Pomatoschistus pictus* (Malm, 1865)**

Gobius affinis: Kolombatović, 1891.

Pomatoschistus pictus adriaticus: Miller, 1972a; Zander & Jelinek, 1976.

The species was recorded for the first time in the Adriatic Sea for the Venice Lagoon (E. Ninni, 1938). Miller (1972a) discovered that syntypes of *Gobius affinis* Kolombatović, 1891 from the Split area in the collection of the Naturhistorischen Museum, Wien belong indeed to *Pomatoschistus pictus*. Miller (1972a) described the subspecies of this species, *Pomatoschistus pictus adriaticus* on specimens from the Split area and on the specimens from the private collection of H. Bath collected at Triest. The samples of *P. pictus* were also collected at Rovinj (Zander & Jelinek, 1976).

***Pomatoschistus quagga* (Heckel, 1840)**

Gobius quagga: Giglioli, 1880; Kolombatović, 1881, 1882, 1891; A. P. Ninni, 1882; Vinciguerra, 1883; Damiani, 1896; Langhoffer, 1904.

Pomatoschistus quagga: Tortonese, 1975; Jardas *et al.*, 1996, 1998; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; De Girolamo *et al.*, 1998; Zavodnik & Kovačić, 2000; Kovačić, 2003.

The species was recorded for the first time in the Adriatic Sea in the Split area (Giglioli, 1880). The species was listed for Venice, the Rijeka Bay, the Kvarner area, the Zadar Channel, the Split area, the Hvar Island, and the Boka Kotorska Bay (Kolombatović, 1881, 1882, 1891; A. P. Ninni, 1882; Vinciguerra, 1883; Damiani, 1896; Langhoffer, 1904; Zavodnik & Kovačić, 2000). The specimens from the Kvarner area, the Žakan Island, the central Adriatic, Split and the Boka Kotorska Bay are deposited in the collection of the Natural History Mu-

seum Rijeka, in the collection of the Museo Civico di Storia Naturale di Genova, in the collection of the Institute of Oceanography and Fisheries, Split and in the collection of Museo di Storia Naturale dell' Università di Firenze (Tortonese, 1975; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, 2003, *unpubl. data*). Specimens were collected by the small scale fishery gear at the Kornati Islands and in the Murter Sea (Jardas *et al.*, 1996). Visual census researches recorded the species at Triest and the Rijeka Bay (De Girolamo *et al.*, 1998; Jardas *et al.*, 1998), without positive identification.

***Pseudaphya ferrerii* (De Buen & Fage, 1908)**

Gobius pusillus: Kolombatović, 1891.

Pseudaphya ferrerii: Miller, 1973b; Kovačić, 2003.

Four males and eight females, collected by Kolombatović as *Gobius pusillus* at Split (the central Adriatic), were found and identified by Miller (1973b) in the collection of the Naturhistorisches Museum Wien. The additional specimens collected at Oštro, Kačjak, and Sv. Marak (the Kvarner area) are deposited in the collection of the Natural History Museum Rijeka (Kovačić, 2003, *unpubl. data*).

***Speleogobius trigloides* Zander & Jelinek, 1976**

Speleogobius trigloides: Zander & Jelinek, 1976; Fesser, 1980; Kovačić, 1997, 2002b.

The holotype was collected at the Banjole cave, near Rovinj, the Istrian Peninsula, in June 1975. It is deposited in the collection of the Zoologisches Institut und Zoologisches Museum der Universität Hamburg. The additional findings were reported from Hvar Island, the central Adriatic, in 1974 and 1975, and Prvić Island in 1977 and 1978 by Fesser (1980). Three females and two males from the Prvić Island (the Kvarner area) are deposited in the collection of the Naturhistorisches Museum Wien. The specimens collected from Žurkovo, the Goli Island, the Prvić Island, Bakar, the Krk Island (the Kvarner area) in the period from 1997 to 2001 are deposited in the collection of the Natural History Museum Rijeka (Kovačić, 1997, 2002b, *unpubl. data*; Zavodnik & Kovačić, 2000).

***Thorogobius ephippiatus* (Lowe, 1839)**

Thorogobius ephippiatus: Miller, 1969; Shultz, 1975; Kovačić, 1994, 1997, 1998; Ahnelt & Kovačić, 1997; Jardas *et al.*, 1998; Zavodnik & Kovačić, 2000; Arko Pijevac *et al.*, 2001; Novosel *et al.*, 2002.

The underwater photograph of this species was taken at the Prvić Island (the Kvarner area) and published in

Riedl (1966) without identification. However, Miller (1969) first identified this species in the Adriatic Sea based on underwater photograph in Riedl (1966) taken at the Prvić Island and sight-record in the Dubrovnik area on August 15 1968. The species was recorded at Banjole near Rovinj in 1962 and collected at the Hvar Island in 1969 and 1970 (Shultz, 1975). The specimens from the Kvarner area are deposited in the collection of the Natural History Museum Rijeka (Kovačić, 1998, *unpubl. data*). The species was also observed at numerous localities in the Kvarner area (Kovačić, 1994, 1997, *unpubl. data*; Ahnelt & Kovačić, 1997; Jardas *et al.*, 1998; Zavodnik & Kovačić, 2000). Benthic biocoenological research recorded the species in the Kvarner area and in the Velebit Channel (Arko Pijevac *et al.*, 2001; Novosel *et al.*, 2002).

***Thorogobius macrolepis* (Kolombatović, 1891)**

Gobius macrolepis: Kolombatović, 1891.

Thorogobius macrolepis: Miller, 1969; Pallaoro & Jardas, 1996; Ahnelt & Kovačić, 1997; Kovačić, 1998; Jardas *et al.*, 1998; Zavodnik & Kovačić, 2000; Arko Pijevac *et al.*, 2001; Novosel *et al.*, 2002.

The species was described on specimens collected in the Split area by Kolombatović (1891). Two syntypes are deposited in the collection of the Naturhistorisches Museum Wien (Miller, 1969; Ahnelt & Kovačić, 1997). Specimens from the Kvarner area are deposited in the collection of the Natural History Museum Rijeka and in the collection of the Institute of Oceanography and Fisheries, Split (Pallaoro & Jardas, 1996; Ahnelt & Kovačić, 1997; Kovačić, 1998, *unpubl. data*). The species was also observed at numerous localities in the Kvarner area (Ahnelt & Kovačić, 1997; Jardas *et al.*, 1998; Zavodnik & Kovačić, 2000). Benthic biocoenological researches recorded the species in the Kvarner area and in the Velebit Channel (Arko Pijevac *et al.*, 2001; Novosel *et al.*, 2002). The record of Novosel *et al.* (2002) was without positive identification of the species. The specimens recorded in Kovačić (1994) belong to another gobiid species, *Gobius roulei*.

***Vanneaugobius dollfusi* (Brownell, 1978)**

Vanneaugobius pruvoti: Jardas, 1996a.

Vanneaugobius dollfusi: Pallaoro & Kovačić, 2000; Ahnelt & Dorda, 2004.

Single male collected near Split in 1931 and single female collected in the Drvenik Channel (the central Adriatic), in 1948, both deposited in the collection of the Institute of Oceanography and Fisheries, Split were identified by Pallaoro & Kovačić (2000). Authors also reported a single female collected near the Mljet Island

and a single juvenile collected by D. Zavodnik near the Palagruža Island in 1998; both deposited in the collection of the Natural History Museum Rijeka. Additional specimens from the Island Palagruža, and locality between the Vis Island and the Biševo Island were found in the collection of the Naturhistorisches Museum Wien and identified by Ahnelt & Dorda (2004).

***Zebrus zebrus* (Risso, 1826)**

Gobius zebrus: Trois, 1875; Kolombatović, 1881, 1891; A. P. Ninni, 1882; E. Ninni, 1912.

Gobius Zebrus: Perugia, 1881.

Zebrus zebrus: Tortonese, 1975; Miller, 1977; Patzner *et al.*, 1991; Kovačić, 1994; 1997, 1998, 2002b; Jardas *et al.*, 1996, 1998; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Zavodnik & Kovačić, 2000; Castellarin *et al.*, 2001; Turk *et al.*, 2002; Lipej *et al.* 2003.

The species was first reported for the Adriatic Sea by Trois (1875), without any notice on collection locality. The first recorded localities in the Adriatic Sea were Zaole and Servola near Trieste (Perugia, 1881) and the Split area (Kolombatović, 1881). Additional specimens were collected at Venice by A. P. Ninni (1882) and in the Split area by Kolombatović (1891). The species was noted as common at Venice (E. Ninni, 1912). Specimens from Venice, Trieste, Medulin, the Kvarner area, the mouth of the river Zrmanja, Pirovac, the Šolta Island, the Kaštela Bay and Mala Duba are deposited in the collection of Museo Civico di Storia Naturale di Venezia, in the collection of the Natural History Museum Rijeka, in the collection of the Museo Civico di Storia Naturale di Genova, in the collection of the Institute of Oceanography and Fisheries, Split, and in the collection of Museo di Storia Naturale dell'Università di Firenze (Tortonese, 1975; Miller, 1977; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, 1998, *unpubl. data*). The species was also noted at numerous localities in the Kvarner area (Kovačić, 1994, 1997; Jardas *et al.*, 1998; Zavodnik & Kovačić, 2000). Benthic biocoenological research recorded the species at the Kornati Islands and the Murter Sea (Jardas *et al.*, 1996). Visual census researches recorded the species at Trieste, the Slovenian coastal waters, and at Kostrena (Patzner *et al.*, 1991; Castellarin *et al.*, 2001; Kovačić, 2002b; Turk *et al.*, 2002; Lipej *et al.* 2003).

***Zosterisessor ophiocephalus* (Pallas, 1811)**

Gobius venetiarum: Nardo, 1860, Trois, 1875.

Gobius lota: Canestrini, 1872; Graeffe, 1888.

Gobius ophiocephalus: Giglioli, 1880; Kolombatović, 1881, 1891; A. P. Ninni, 1882; Vinciguerra, 1883; Langhoffer, 1904; Cavinato, 1952; Marcuzzi, 1972; E. Ninni, 1912, 1938; Usić, 2003.

Zosterisessor ophiocephalus: Tortonese, 1975; Balestra *et al.*, 1989; Mušin, 1989; Kraljević & Pallaoro, 1991; Lahnsteiner *et al.*, 1992; Zavodnik & Crnković, 1992; Giulianini *et al.*, 1994; Caputo *et al.*, 1996, 1997; Jardas *et al.*, 1996; Marconato *et al.*, 1996; Ota *et al.*, 1996; Ota & Lahnsteiner, 1996; Pallaoro & Jardas, 1996; McKay & Miller, 1997; Orepić *et al.*, 1997; Caputo, 1998; Kovačić, 1998; Ota *et al.*, 1999; Scaggiante *et al.*, 1999; Sorice & Caputo, 1999; Marchesan *et al.*, 2000; Mazzoldi *et al.*, 2000; Torricelli *et al.*, 2000; Pallaoro, 2001; Franco *et al.*, 2002; Malavasi *et al.*, 2002, 2003; Usić, 2003; Dulčić, 2004.

Zosterisessor ophiocephalus: Nocita & Vanni, 1997.

The species was recorded for the first time in the Adriatic Sea at Venice (Nardo, 1860). The species was listed under various synonyms for the Venice Lagoon, Trieste, the Krk Island, the Ugljan Island, the Murter Island, the Split area, the Šolta Island, the Brač Island, the Hvar Island, the Vis Island, the Mljet Island, the Lastovo Island, the Korčula Island, and the Boka Kotorska Bay (Canestrini, 1872; Trois, 1875; Giglioli, 1880; Kolombatović, 1881, 1891; A. P. Ninni, 1882; Vinciguerra, 1883; Graeffe, 1888; Langhoffer, 1904; E. Ninni, 1912, 1938; Cavinato, 1952). The specimens from Chioggia, the Venice Lagoon, Trieste, Rovinj, the Pag Island, the Šibenik area, Dalmatia, the Split area, the Šolta Island, the Dubrovnik area, the mouth of the river Neretva, and Bari are deposited in the collection of the Museo Zoologico di Padova, in the collection of the Center for Marine Research of the Ruđer Bošković Institute in Rovinj, in the collection of the Natural History Museum Rijeka, in the collection of the Institute of Oceanography and Fisheries, Split, in the collection of the Natural History Museum of the Biological Institute, Dubrovnik, in the collection of l'Istituto di Idrobiologica di Chioggia, and in the collection of Museo di Storia Naturale dell'Università di Firenze (Marcuzzi, 1972; Tortonese, 1975; Mušin, 1989; Pallaoro & Jardas, 1996; Nocita & Vanni, 1997; Kovačić, 1998; Usić, 2003). Specimens were collected by the small scale fishery gear at the Kornati Islands, the Murter Sea, and the Split area (Kraljević & Pallaoro, 1991; Jardas *et al.*, 1996; Pallaoro, 2001). Benthic biocoenological researches recorded the species at the Lošinj Island, the Kornati Islands, the Murter Sea, and the Mljet Island (Zavodnik & Crnković, 1992; Jardas *et al.*, 1996; Orepić *et al.*, 1997). Visual census research recorded the species in the Slovenian coastal waters (Turk *et al.*, 2002). The samples of this species were also collected in the Venice Lagoon, near Grado, near Trieste, at Ancona, and in the Karin Sea (Balestra *et al.*, 1989; Lahnsteiner *et al.*, 1992; Giulianini *et al.*, 1994; Caputo *et al.*, 1996, 1997; Marconato *et al.*, 1996; Ota *et al.*, 1996; Ota & Lahnsteiner, 1996; McKay & Miller, 1997; Caputo, 1998; Ota *et al.*, 1999; Scaggiante *et al.*, 1999;

Sorice & Caputo, 1999; Marchesan *et al.*, 2000; Maz-zoldi *et al.*, 2000; Torricelli *et al.*, 2000; Franco *et al.*, 2002; Malavasi *et al.*, 2002, 2003; Dulčić, 2004).

SPECIES EXCLUDED FROM THE CHECKLIST

The following species listed for the Adriatic Sea in the last published checklist by Jardas (1996a), should be excluded from the checklist for the Adriatic Sea:

***Gobius luteus* Kolombatović, 1891**

Kolombatović (1891) described the variant of *G. auratus* as *G. auratus* v. *lutea*. Miller & El-Tawil (1974) raised this variant to species level as *G. luteus*. Heymer & Zander (1992) described new species, *Gobius xanthocephalus*, from western Mediterranean. Authors agreed with Miller (1973a) that *G. auratus* v. *ruginosa* was *G. fallax* and concluded that the variant *lutea* was not a separate species, but the typical form of *G. auratus* (Heymer & Zander, 1992). Consequently, *G. luteus* is a junior synonym of *G. auratus*, and not a valid species.

***Gobius strictus* Fage, 1907**

Single female collected at the Korčula Island (the central Adriatic) was found and identified by Miller (1967) as *Gobius schmidtii* in the collection of the Museo Civico di Storia Naturale di Genova. Miller (1973a) listed *Gobius schmidtii* by Miller (1967) as a junior synonym of *Gobius strictus* Fage, 1907. The later suggestion of Miller (1986) that specimens of this species could be juveniles of *G. cruentatus* was confirmed by Kovačić (2004). Therefore, *G. strictus* is a junior synonym of *G. cruentatus*, and not the valid species.

***Gobiusculus flavescens* (Fabricius, 1779)**

Nardo (1860) listed *Gobius ruthensparii* (error for *ruuthensparri*) for the Venice area. Perugia (1866) listed *Gobius ruthensparri* for the Triest area without any data for positive identification. *Gobius ruthensparii* was cited by rote for the Adriatic Sea (Canestrini, 1872; Trois, 1875; Giglioli, 1880; Stossich, 1880; Perugia, 1881; Faber, 1883; Carus, 1893) with these or different spelling errors. A. P. Ninni, (1882) excluded this species from his catalogues of gobies of the Adriatic Sea. Damiani (1896) suspected that *G. Ruthensparri* (error for *ruuthensparri*) was doubtful citation by Nardo, since the species is known from the northern Atlantic. E. Ninni (1912) and Šoljan (1948, 1965) excluded this synonym from their lists of the Adriatic fishes. E. Ninni (1938) was convinced in wrong identification of *G. ruthensparii* by Nardo. The species was listed for the first time under the valid synonym *Gobiusculus flavescens* (Fabricius, 1779) by Bini (1969). This was again a citation based only on

the list published by Nardo (1860). However, a new era of citations of this species for the Adriatic Sea began with Bini (1969), following the valid name (Tortonese, 1975; Štević, 1977; Jardas, 1985, 1996a; Kovačić, 1994). Miller (1986) listed this species just for the eastern Atlantic. According to presented data, there is no evidence for the presence of *G. flavescens* in the Adriatic Sea.

***Pomatoschistus microps* (Krøyer, 1838)**

E. Ninni (1938) and Cavinato (1952) recorded this species for the Venice area. All subsequent notices of this species for the Adriatic Sea (Šoljan, 1948, 1965; Bini, 1969; Vuković i Ivanović, 1971; Tortonese, 1975; Štević, 1977; Jardas, 1985, 1996a; Kovačić, 1994) were based on the original data by E. Ninni (1938) and Cavinato (1952). Miller (1972c, 1973a) suggested that descriptions by E. Ninni (1938) and Cavinato (1952) referred to *Knipowitschia* species. Miller (1986) and Ahnelt (1991) listed this species just for the eastern Atlantic and the northwestern coast of Mediterranean. Specimens collected by the bottom trawl between the mid-Dalmatian islands were undoubtedly wrongly identified as *Gobius microps laticeps* (Županović, 1961). According to presented data, the specimens identified as *P. microps* in the Venice area, belong to *Knipowitschia* species.

***Pomatoschistus tortonesei* (Miller, 1968)**

The species was mentioned for the first time for the Adriatic Sea by Štević (1977), based on personal communication from Miller on specimens from the Boka Kotorska Bay. All later citations of this species for the Adriatic Sea (Jardas, 1985, 1996a; Kovačić, 1994) were based on data by Štević (1977). Miller (1982) described *Pomatoschistus bathi*, and redescribed *P. tortonesei*. The specimens from the Boka Kotorska Bay were identified as *P. bathi*. All specimens of *P. tortonesei* studied for re-description of the species (Miller, 1982) were not collected in the Adriatic Sea. Miller (1986) listed *P. tortonesei* just for the central Mediterranean. According to the above data, the specimens identified in the first place as *P. tortonesei* from the Boka Kotorska Bay (Štević, 1977), belong to *P. bathi*.

***Vanneaugobius pruvoti* (Fage, 1907)**

Single male collected near Split in 1931 and single female collected in the Drvenik Channel (the central Adriatic) in 1948 deposited in the collection of the Institute of Oceanography and Fisheries, Split were re-identified as *Vanneaugobius dollfusi* Brownell, 1978 by Pallaoro & Kovačić (2000).

DISCUSSION

The sources of data for this checklist of the Adriatic Sea gobies were ichthyological lists containing original collection data, papers on taxonomy and zoogeography of gobies, fisheries papers, benthic biocoenological papers, papers on fish visual census and papers on various researches that used samples of Adriatic gobies. Studies on taxonomy and zoogeography of gobies were by the far most important contributions to the checklist among all these sources of data. Eight species were added to the last published list (Jardas, 1996a): *Didogobius splechnai*, *Gammogobius steinitzi*, *Gobius ater*, *Gobius couchi*, *Gobius kolombatovici*, *Lebetus guiletti*, *Pomatoschistus norvegicus*, and *Vanneaugobius dollfusi* (Kovačić, 1999, 2001a; Kovačić & Miller, 2000; Pallaoro & Kovačić, 2000; Stefanni, 2000; Ahnelt, 2001; Herler & Patzner, 2002; Herler & Kovačić, 2002). All these species, except of *Gobius ater*, were included in new fish records for the Adriatic Sea by Lipej & Dulčić (2004).

Six species were excluded from the checklist of the Adriatic gobies, based on evidence referred in the present review. Some other errors were also found in the previous checklists. The doubtful status of *K. caucasica* in the Adriatic Sea, questioned by Economidis & Miller (1990), and resolved by Kovačić & Pallaoro (2003), was overlooked by checklists published in the meantime. Absence of evidence on the presence of *B. affinis* (Miller, 1972a) was also ignored by later reviews, until true specimens of *B. affinis* were found for the first time in the Adriatic Sea thirty years later (Kovačić, 2002b). The confusion on *Vanneaugobius* was the briefest one, it lasted for only five years (Jardas, 1996a; Pallaoro & Kovačić, 2001). The presented checklist contains 46 gobiid species recorded in the Adriatic Sea up to the present date. Four Adriatic gobies could still be considered Adriatic endemic species: *Gobius kolombatovici*, *Knipowitschia panizzae*, *Pomatoschistus canestrinii* and *Speleogobius trigloides*. Today 59 species of Gobiidae are known to occur in the Mediterranean *sensu stricto* if we exclude *Gobius strictus* and *Gobius luteus* (Heymer & Zander, 1992; Kovačić, 2004) from 61 species listed for the Mediterranean (Quignard & Tomasini, 2000; Ahnelt & Dorda, 2004). The thirteen gobies recorded in the Mediterranean, and not found in the Adriatic Sea, are the Atlantic species (7 species), the Red Sea invaders (3 species), and the Mediterranean endemic species (3 species).

Three valid gobiid genera, twelve valid gobiid spe-

cies and two valid subspecies were described on the Adriatic specimens (Verga 1841; Steindachner, 1861; Steindachner, 1863; Steindachner, 1870; A. P. Ninni, 1883; Kolombatović, 1891; Miller, 1969, 1971, 1972a, 1972b; Bath, 1973; Zander & Jelinek, 1976; Miller, 1992; Kovačić & Miller, 2000). The most fruitful periods for Adriatic gobiology were from 1860 to 1900 with eight newly described species and ten first findings for the Adriatic Sea, and from 1968 to 2002 with three newly described species and fifteen first findings for the Adriatic Sea. The largest contributions were provided by Kolombatović (four species description and three first findings for the Adriatic Sea), Steindachner (three species description and one first finding for the Adriatic Sea), Miller (two species description and five first findings for the Adriatic Sea), and Kovačić (one species description and six first findings for the Adriatic Sea). The locations of eight gobiid types (holotype, syntypes or neotypes) from the Adriatic Sea are known from published sources (Tortonese, 1963; Miller, 1969, 1972b, 1973a, 1992; Bath, 1973; Zander & Jelinek, 1976; Kovačić & Miller, 2000). Adriatic types of the three species are deposited in the collection of the Naturhistorisches Museum Wien, and types of the one species in each of the following collections: the collection of the Museo Civico di Storia Naturale di Genova, the collection of the Senckenberg Naturmuseum, Frankfurt, the collection of the Zoologisches Institut und Zoologisches Museum der Universität Hamburg, the collection of the Zoologische Staatssammlung, München, and the collection of the Natural History Museum Rijeka. The richest collections in Adriatic gobiid species are the collection of the Natural History Museum Rijeka (39 Adriatic species), the collection of the Institute of Oceanography and Fisheries, Split (28 Adriatic species), the collection of Museo di Storia Naturale dell'Università di Firenze (20 Adriatic species), and the collection of the Naturhistorisches Museum Wien (13 Adriatic species).

ACKNOWLEDGEMENTS

I am grateful to D. Zavodnik for criticism and comments on this paper. I thank D. Čaleta, Ž. Modrić, M. Vučemilović and D. Zavodnik for help in search for literature. This paper is the second publication of the dissertation of the author, which was carried out at the University of Zagreb, Croatia under the supervision of I. Jardas in 2004.

Tab. 1: List of gobiid species recorded in the Adriatic Sea up to the present date.

Tab. 1: Seznam glavačev, do danes ugotovljenih v Jadranskem morju.

No.	Species
1	<i>Aphia minuta mediterranea</i> De Buen, 1931
2	<i>Buenia affinis</i> Iljin, 1930
3	<i>Chromogobius quadrivittatus</i> (Steindachner, 1863)
4	<i>Chromogobius zebratus zebratus</i> (Kolombatović, 1891)
5	<i>Corcyrogobius liechtensteini</i> (Kolombatović, 1891)
6	<i>Crystallogobius linearis</i> (Von Döben, 1845)
7	<i>Deltentosteus colonianus</i> (Risso, 1826)
8	<i>Deltentosteus quadrimaculatus</i> (Valenciennes, 1837)
9	<i>Didogobius schliweni</i> Miller, 1992
10	<i>Didogobius splechnai</i> Ahnelt & Patzner, 1995
11	<i>Gammogobius steinitzi</i> Bath, 1971
12	<i>Gobius ater</i> Bellotti, 1888
13	<i>Gobius auratus</i> Risso, 1810
14	<i>Gobius bucchichi</i> Steindachner, 1870
15	<i>Gobius cobitis</i> Pallas, 1811
16	<i>Gobius couchi</i> Miller & El-Tawil, 1974
17	<i>Gobius cruentatus</i> Gmelin, 1789
18	<i>Gobius fallax</i> Sarato, 1889
19	<i>Gobius geniporus</i> Valenciennes, 1837
20	<i>Gobius kolombatovici</i> Kovačić & Miller, 2000
21	<i>Gobius niger</i> Linnaeus, 1758
22	<i>Gobius paganellus</i> Linnaeus, 1758
23	<i>Gobius roulei</i> De Buen, 1928
24	<i>Gobius vittatus</i> Vinciguerra, 1883
25	<i>Knipowitschia caucasica</i> (Kawrajsky, 1916)
26	<i>Knipowitschia panizzeae</i> (Verga, 1841)
27	<i>Lebetus guilleleti</i> (Le Danois, 1913)
28	<i>Lesueurigobius friesii</i> (Malm, 1874)
29	<i>Lesueurigobius suerii</i> (Risso, 1810)
30	<i>Millerigobius macrocephalus</i> (Kolombatović, 1891)
31	<i>Odondebuenia balearica</i> (Pellegrin & Fage, 1907)
32	<i>Pomatoschistus bathi</i> Miller, 1982
33	<i>Pomatoschistus canestrinii</i> (Ninni, 1883)
34	<i>Pomatoschistus knerii</i> (Steindachner, 1861)
35	<i>Pomatoschistus marmoratus</i> (Risso, 1810)
36	<i>Pomatoschistus minutus</i> (Pallas, 1770)
37	<i>Pomatoschistus norvegicus</i> (Collett, 1903)
38	<i>Pomatoschistus pictus adriaticus</i> Miller, 1972
39	<i>Pomatoschistus quagga</i> (Heckel, 1840)
40	<i>Pseudaphya ferreri</i> (De Buen & Fage, 1908)
41	<i>Speleogobius trigloides</i> (Zander & Jelinek, 1976)
42	<i>Thorogobius ephippiatus</i> (Lowe, 1839)
43	<i>Thorogobius macrolepis</i> (Kolombatović, 1891)
44	<i>Vanneaugobius dollfusi</i> (Brownell, 1978)
45	<i>Zebrus zebrus</i> (Risso, 1826)
46	<i>Zosterisessor ophiocephalus</i> (Pallas, 1811)

SEZNAM VRST IZ DRUŽINE GOBIIDAE V JADRANSKEM MORJU

Marcelo KOVAČIĆ

Prirodoslovni muzej Rijeka, HR-51000 Rijeka, Lorenzov prolaz 1, Hrvatska

E-mail: Marcelo.Kovacic@public.srce.hr

POVZETEK

Avtor predstavlja popoln seznam 46 vrst jadranskih glavačev. Zbrani in na novo pregledani so bili vsi obstoječi podatki o pojavljanju teh vrst v Jadranskem morju. Seznam je bil napravljen na osnovi znanstvene literature in neobjavljenih podatkov iz ihtiološke zbirke, ki jo hranijo v Prirodoslovnem muzeju na Reki. Zaradi dokazov, navedenih in pojasnjenih v tem pregledu, je bilo s prejšnjih seznamov jadranskih glavačev, na katerih je bilo odkritih tudi več drugih napak, črtanih šest vrst. Sicer pa velja, da v Jadranskem morju še vedno ni bilo odkritih trinajst vrst, doslej zabeleženih v Sredozemskem morju. Na osnovi primerkov, ujetih v Jadranskem morju, so doslej opisali tri veljavne rodove, dvanaest veljavnih vrst in dve veljavni podvrsti glavačev. Jadranska gobiologija je bila najuspešnejša v obdobju med letoma 1860 in 1900 z osmimi prvič objavljenimi vrstami in desetimi prvič najdenimi vrstami v Jadranskem morju in med letoma 1968 in 2002 s tremi prvič objavljenimi in petnajstimi prvič najdenimi vrstami jadranskih glavačev.

Ključne besede: seznam, Gobiidae, Jadransko morje

REFERENCES

- Ahnelt, H. (1984):** Zur Kenntnis von *Gobius bucchichi* Steindachner, 1870 und *Gobius fallax* Sarato, 1889 (Pisces, Gobiidae). Ann. Nathist. Mus. Wien B, 86, 1–5.
- Ahnelt, H. (1990):** *Chromogobius quadrivittatus*, *Chromogobius zebratus* und *Zebrus zebrus* (Pisces, Gobiidae): Erstnachweise für Korsika (Frankreich) und Sardinien (Italien). Ann. Nathist. Mus. Wien B, 91, 27–41.
- Ahnelt, H. (1991):** Some rare fishes from the western Mediterranean Sea. Ann. Nathist. Mus. Wien, 92, 49–58.
- Ahnelt, H. (2001):** Two Mediterranean gobiid fishes with an unusual cephalic lateral line canal system. Cybium, 25(3), 261–267.
- Ahnelt, H. & B. Elvira (1991):** Eine Kollektion von Meeres- und Süßwasserfischen der Österreichischen Adria-Tiefsee-Expedition 1894. Ann. Nathist. Mus. Wien B, 92, 1–13.
- Ahnelt, H. & M. Kovačić (1997):** A northern Adriatic population of *Thorogobius macrolepis* (Teleostei: Gobiidae). Cybium, 21(2), 149–162.
- Ahnelt, H. & J. Dorda (2004):** Gobioid fishes from the north eastern Atlantic and the Mediterranean: new records and rarely found species. Ann. Nathist. Mus. Wien B, 105, 5–19.
- Ahnelt, H., P. J. Miller & R. A. Patzner (1994):** Systematic and distribution of two rare Mediterranean gobies, *Corcyrogobius liechtensteini* (Kolombatović, 1891) and *Odondebuenia balearica* (Pellegrin & Fage, 1907) (Teleostei: Gobiidae). Cybium, 18(2), 169–176.
- Arko Pijevac, M., Č. Benac, M. Kovačić & M. Kirinčić (2001):** A submarine cave at the Island of Krk (North Adriatic Sea). Nat. Croat., 10, 163–184.
- Atkinson, R. J. A., C. Froglija, F. Arneri & B. Antolini (1998):** Observations on the burrows and burrowing behaviour of *Brachynotus gemmellari* and on the burrows of several other species occurring on *Squilla* grounds off Ancona, Central Adriatic. Scient. Mar., 62(1–2), 91–100.
- Balestra, M., E. A. Ferrero, P. G. Gulianini, R. Marzari, D. Ota & R. Patzner (1989):** Preliminary identification of yolk proteins as molecular markers of ovarian maturation in *Zosterisessor ophiocephalus* (Pisces: Gobiidae). EAS Special Publication, 10, 19–20.
- Bath, H. (1973):** Wiederbeschreibung der Grundelart *Gobius macrocephalus* Kolombatović aus dem Mittelmeer und Aufstellung einer neuen Gattung *Millerigobius*. Senckenb. Biol., 54, 303–310.
- Brünnich, M. T. (1768):** Ichthyologia Massiliensis, sistens piscium descriptiones eorumque aoud incolae nomina, accedunt spolia maris Adriatici. Copenhagen & Leipzig: Rothii, Viduam et Proft.
- Bellotti, C. (1879):** Note ittologiche. Atti Soc. Ital. Sci. nat., 22, 33–38.
- Bini, G. (1969):** Atlante dei Pesci delle Coste Italiane. Vol. 7. Mondo sommerso ed., Milano.
- Brusina, S. (1891):** Dva popisa dalmatinskih riba od M. Botteri-a s dodacima Hacckel-a, Bellotti-a, Stalio-a i dr. i s uvodom od S. Brusine. Glasnik Hrv. Naravosl. Društva, 6, 110–151.
- Canestrini, G. (1872):** Pesci. Fauna d'Italia. Parte Terza. Francesco Vallardi Editore, Milano.
- Caputo, V. (1998):** Nucleolar organizer (NOR) location and cytotoxic implications in six species of gobiid fishes (Perciformes, Gobiidae). Ital. J. Zool., 65, 93–99.
- Caputo, V., R. Vitturi, G. Odeirna, J. Cano, E. Olmo & M. S. Colomba (1996):** Characterization of mitotic chromosomes in the gobiid fish *Zosterisessor ophiocephalus* (Pallas, 1811) (Perciformes, Gobiidae). Biol. Zent. bl., 115, 328–336.
- Caputo, V., F. Marchegiani, M. Sorice & E. Olmo (1997):** Heterochromatin heterogeneity and chromosome variability in four species of gobiid fishes (Perciformes: Go-

biidae). Cytogenet. Cell Genet., 79, 266–271.

Caputo, V., M. L. Caniglia & N. Machella (1999): The chromosomal complement of *Aphia minuta*, a paedomorphic goby. J. Fish Biol., 55, 455–485.

Caputo, V., M. La Mesa, G. Candi & P. N. Cerioni (2003): The reproductive biology of the crystal goby with a comparison to that of the transparent goby. J. Fish Biol., 62, 375–385.

Carrara, F. (1846): La Dalmazia descritta. Fratelli Batava Ed., Zara.

Carus, J. V. (1893): Prodromus faunae Mediterraneae. II. E. Schweizerbart, Stuttgart.

Castellarin, C, G. Visintin & R. Odorico (2001): L'ittiofauna della Riserva naturale marina di Miramare (Golfo di Trieste, alto Adriatico). Annales Ser. Hist. Nat., 11(2), 207–216.

Cavinato, G. (1952): Revisione del *Gobius* della Laguna Veneta. Arch. Oceanogr. Limnol., 7, 1–56.

Cetinić, P. & A. Pallaoro (1990a): Analiza lovina kogola i ocjena njegove štetnosti. Mor. rib., 42(4), 113–125.

Cetinić, P. & A. Pallaoro (1990b): Analiza lovina strašina i ocjena njegove štetnosti. Mor. rib., 42(2), 49–55.

Crnković, D. (1970): Prilog biološkoj i ekonomskoj problematici kočarenja u kanalskom području sjeveroistočnog Jadrana. Thalassia Jugosl., 6, 5–90.

Crnković, D. (2001): Problemi ribarstva i okoliša Kvarnerskog područja. Prirodoslovna biblioteka 2. Prirodoslovni muzej Rijeka, Rijeka.

D'Ancona, U. (1922): Notizie sulla pesca nel Golfo di Fiume. Mem. R. Comit. Talassia Ital., 94, 3–28.

Damiani, G. (1896): I *Gobius* italici a proposito di un raro *Gobius* del Mediterraneo (*Gobius colonianus* Risso). Riv. Ital. Sci. Nat., Siena, 16, 58–62, 77.

De Girolamo, M., S. Stefanni, M. Mazzoldi & R. Odorico (1998): Effetti della totale proibizione della pesca sul popolamento ittico del Parco di Miramare (Ts): analisi preliminare. Boll. Mus. Civ. Stor. Nat. Venezia, 49, 311–315.

Dulčić, J. (2004): Incidence of the spinal deformities in natural populations of grass – goby, *Zosterisessor ophiocephalus* from Karin Sea, Eastern Middle Adriatic. Cybium, 28, 7–11.

Economidis, P. S. & P. J. Miller (1990): Systematics of freshwater gobies from Greece. J. Zool. Lond., 221, 125–170.

Faber, G. L. (1883): The fisheries of the Adriatic and the fish thereof. B. Quaritch, London.

Fabi, G. & C. Froglija (1983): Food and feeding of *Gobius niger* L. in the Central Adriatic Sea (Osteichthyes: Gobiidae). Rapp. Comm. int. Mer Médit., 28(5), 99–102.

Fabi, G. & C. Froglija (1984): A note on the biology and fishery of the black goby (*Gobius niger*) in the Adriatic Sea. FAO Fish. Rep., 290, 167–170.

Fabi, G. & G. Gianetti (1985): Growth parameters of the black goby (*Gobius niger* L.) in the Adriatic Sea, based on otoliths reading. Rapp. Comm. int. Mer Médit., 29, 87–90.

Fesser, R. (1980): Zusätzliche Beschreibung von *Speleogobius trigloides* Zander & Jelinek (1976) (Gobiidae, Perciformes), sowie neue Fundorte und –Freilandbeobachtungen. Verhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, 118/119, 123–126.

Franco, A., S. Malvasi, F. Pranovi, P. Franzoi & P. Torricelli (2002): Preliminary data on gonadal development and fecundity in the Grass goby, *Zosterisessor ophiocephalus* (Pallas, 1811) from the Venice (northern Italy). Acta Adriat., 43(2), 43–48.

Froglija, C. & M. E. Gramitto (1982): Alcuni aspetti biologici e gestionali della pesca a strascico sui "Fondi a Scampi" dell' Adriatico centrale. Atti. Conv. Unità. Oper. Aff. sottopr., Risorse Biol. Inquinam. Marino, Roma, p. 295–309.

Froglija, C. & M. E. Gramitto (1989): La pesca del rosetto (*Aphyia minuta*) nel Medio Adriatico. Biol. Mar. Medit., 5(3), 503–512.

Gamulin-Brida, H., Z. Pavletić, D. Crnković, A. Požar-Domac, M. Legac & Ž. Žutić-Maloseja (1980): Prilog poznavanju bentosa infralitorala u području jugozapadne obale otoka Krk. Acta Adriat., 21(2), 355–367.

Gandolfi, G. (1972): Osservazioni sul comportamento riproduttivo di *Knipowitschia panizzae* (Osteichthyes, Gobiidae). Boll. Zool., 45, 215.

Gandolfi, G. & P. Tongiorgi (1976): La presenza di *Knipowitschia panizzae* (Verga) in acque lagunari ed estuariali Tirreniche (Osteichthyes, Gobiidae). Atti. Soc. Tosc. Sc. Nat. Mem., 83, 1–9.

Gandolfi, G., P. Torricelli & A. Cau (1982): Osservazioni sulla biologia del ghiozzeto cenerino, *Pomatoschistus canestrinii* (Ninni) (Osteichthyes, Gobiidae). Nova Thalassia, 5, 97–123.

Giglioli, E. H. (1880): Elenco del Mammiferi, degli Uccelli e dei Retili ittiofagi appartenenti alla Fauna italiana, e Catalogo degli Anfibi e Pesci italiani. Catalogo Sezione italiana, Esposizione internazionale della Pesca, Berlino, 1880. Stamperia Reale, Firenze.

Giulianini, P. G., A. Marcotullio & E. A. Ferrero (1994): Light microscopical and ultrastructural cytology of the ovaries in the sea-grass goby *Zosterisessor ophiocephalus* (Osteichthyes, Gobiidae). Boll. Zool., 61, 135–144.

Graeffe, E. (1888): Uebersicht der Seetiere des Golfes von Triest. IV. Pisces (Fische). Arbeiten des Zoolog. Institutes zu Wien u. Zool. Stat. Triest., 7, 445–470.

Gridelli, E. (1931): Note d'ittologia adriatica. Atti Mus. Civ. Stor. Nat. Trieste, 11(1), 368–377.

Griffini, A. (1903): Ittiologia Italiana. Ulrico Hoepli, Milano.

Guidetti, P. (2000): Differences Among Fish Assemblages Associated with Nearshore *Posidonia oceanica* Seagrass Beds, Rocky-algal Reefs and Unvegetated Sand Habitats in the Adriatic Sea. Estuar. Coast. Shelf Sci., 50, 515–529.

Guidetti, P. & S. Bussotti (2000): Nearshore fish assemblages associated with shallow rocky habitats along the

southern Croatian coast (Eastern Adriatic Sea). *Vie Milieu*, 50, 171–176.

Herler, J. & M. Kovačić (2002): *Lebetus guiletti* (Teleostei: Gobiidae) in the northern Adriatic Sea: First record and details in the species' morphology. *Annales Ser. Hist. Nat.*, 12(2), 177–188.

Herler, J. & R. A. Patzner (2002): New records of *Didogobius splechnai* (Gobiidae) from the Tyrrhenian and Northern Adriatic Sea. *Cybium*, 26(2), 153–155.

Herler, J., R. A. Patzner & C. Sturmbauer (2005): A preliminary revision of the *Gobius auratus* species complex with redescription of *Gobius auratus* Risso, 1810. *J. Nat. Hist.*, 39, 1043–1075.

Heymer, A. & C. D. Zander (1992): Feeding habits of *Gobius auratus* and other benthic small-sized fish from the French Mediterranean coast under regard of some alternating parameters. *Zool. Anz.*, 228, 220–228.

Jaklin, A. & M. Arko-Pijevac (1997): Benthic biocoenosis of the Sv. Marko Islet (Rijeka Bay). *Period. Biol.*, 99(2), 219–228.

Jardas, I. (1985): Pregled riba (*sensu lato*) Jadranskog mora (Cyclostomata, Selachii, Osteichthyes) s obzirom na taksonomiju i utvrđeni broj. *Biosistematika*, 11(1), 45–74.

Jardas, I. (1996a): Jadranska ihtiofauna. Školska knjiga, Zagreb, 535 pp.

Jardas, I. (1996b): Sastav pridnenih ihtionaselja Murterskog mora. Simpozij Nacionalni park Kornati. Priopćenja. Ekološke monografije, 7, 343–351.

Jardas, I. & A. Pallaoro (1989): Neki pokazatelji opadanja biološkog bogatstva priobalnog područja Jadrana (1960–1988). *Pogledi*, 19, 159–176.

Jardas, I., S. Jukić, I. Kačić, S. Regner & S. Gorenka (1981): Ribarstveno-biološka istraživanja šireg područja Malostonskog zaljeva. Savjetovanje Malostonski zaljev – prirodna podloga i društveno valoriziranje. JAZU, Dubrovnik, 12–14. studenog, 1981, p. 175–202.

Jardas, I., A. Pallaoro & D. Zavodnik (1996): Ihtiofauna područja Kornata i Murterskog mora. Simpozij Nacionalni park Kornati. Priopćenja. Ekološke monografije, 7, 353–377.

Jardas I., A. Pallaoro & M. Kovačić (1998): Recent ichthyofauna of Rijeka Bay. In: Arko-Pijevac, M., M. Kovačić & D. Crnković (eds): *Zbornik radova Prirodoslovna istraživanja riječkog područja*, p. 671–685.

Jukić, S. (1975): Kočarska područja u srednjem Jadranu. *Acta Adriat.*, 17, 1–87.

Jukić, S. (1983): Kočarska naselja Crnogorskog primorja i dozvoljeni nivo iskorištavanja. *Studia Marina*, 13–14, 155–165.

Jukić, S. & D. Crnković (1974): Stanje naselja pridnenih jestivih vrsta u Jadranu. *Acta Adriat.*, 16, 137–156.

Jukić, S. & C. Piccinetti (1981): Quantitative and qualitative characteristics of demersal resources in the Adriatic Sea with some population dynamics estimates. *FAO Fish. Rep.*, 253, 73–91.

Kolombatović, J. (1881): Pesci delle acque di Spalato e

catalogo degli anfibi e dei rettili dei contorni di Spalato. Estratto dal programma dell' i. r. Scuola reale Superiore, p. 1–29.

Kolombatović, J. (1882): Mammiferi, anfibi e rettili, e pesci rari e nuovi per l'Adriatico catturati nelle acque di Spalato. Godišnje izvješće C. K. Velike realke u Splitu za školsku godinu 1881/82, p. 27–35.

Kolombatović, J. (1886): Imenik kraljevnjaka Dalmacije. II. dio: Dvoživci, gmazovi i ribe. Godišnje izvješće C. K. Velike realke u Splitu za školsku godinu 1885/86, p. 2–32.

Kolombatović, J. (1888): Catalogus vertebratorum dalmaticorum. Godišnje izvješće C. K. Velike realke u Splitu za školsku godinu 1887/88, p. 2–32.

Kolombatović, J. (1891): Glamoči (Gobii) Spljetskog Pomorskog Okružja. Godišnje izvješće C.K. Velike realke u Splitu za školsku godinu 1890–91, p. 1–29.

Kolombatović, J. (1900): Druge zoologičke vijesti iz Dalmacije. Program C.K. Velike realke u Splitu za školsku godinu 1899–900, p. 1–34.

Kovačić, M. (1994): Contribution to the knowledge of gobies, Gobiidae (Pisces, Perciformes) in the Rijeka Bay, Adriatic Sea. *Period. Biol.*, 96(4), 463–465.

Kovačić, M. (1995): *Gobius roulei* De Buen, 1928 (Pisces, Teleostei, Gobiidae), a Fish new to the Adriatic Fauna. *Nat. Croat.*, 4(4), 173–184.

Kovačić, M. (1997): Cryptobenthic gobies and clingfishes in the Kvarner area, Adriatic Sea. *Nat. Croat.*, 6(4), 423–435.

Kovačić, M. (1998): Ichthyological collection (Cyclostomata, Selachii, Osteichthyes) of the Natural History Museum Rijeka. In: Arko-Pijevac, M., M. Kovačić & D. Crnković (eds): *Prirodoslovna istraživanja riječkog područja*. Zbornik radova, p. 685–698.

Kovačić, M. (1999): *Gammogobius steinitzi* Bath, 1971, a fish new to the Adriatic Sea. *Nat. Croat.*, 8(1), 1–7.

Kovačić, M. (2001a): The Kvarner population of *Gobius couchi* (Teleostei, Gobiidae), a fish new to the Adriatic fauna. *Nat. Croat.*, 10(1), 1–10.

Kovačić, M. (2001b): The biology of Roule's goby in the Kvarner area, northern Adriatic Sea. *J. Fish Biol.*, 59(4), 795–809.

Kovačić, M. (2002a): A northern Adriatic population of *Buenia affinis* (Gobiidae). *Cybium*, 26, 197–201.

Kovačić, M. (2002b): A visual census of the coastal fish assemblage at Kostrena (the Kvarner area, Croatia). *Annales Ser. Hist. Nat.*, 12(1), 1–8.

Kovačić, M. (2003): Hyperbenthic gobies in the Kvarner area, Adriatic Sea. *J. Fish Biol.*, 63(4), 1051–1055.

Kovačić, M. (2004): Unusual morphological and ecological characteristics of hyperbenthic juveniles of *Gobius cruentatus*. *J. Fish Biol.*, 65, 545–558.

Kovačić, M. & P. J. Miller (2000): A new species of *Gobius* (Teleostei: Gobiidae) from the northern Adriatic Sea. *Cybium*, 24, 231–239.

Kovačić, M. & A. Pallaoro (2003): Is *Knipowitschia cau-*

casica-like form from the Adriatic Sea a new Goby species? Evidence from a morphological approach in the Eastern Adriatic Sea. *Cybum*, 27, 81–164.

Kraljević, M. & A. Pallaoro (1991): Ihtiocenoze plitkih uvala nacionalnog parka "Kornati". *Morsko ribarstvo*, 43(3), 81–90.

La Mesa, M. (1999): Age and growth of *Aphia minuta* (Pisces, Gobiidae) from central Adriatic Sea. *Sci. Mar.*, 63, 147–155.

La Mesa, M. (2001): Age and growth of *Crystallogobius linearis* (von Düben, 1845) (Teleostei: Gobiidae) from the Adriatic Sea. *Sci. Mar.*, 65, 375–381.

Lahnsteiner, F., M. Seiwald, R. A. Patzner & E. A. Ferrero (1992): The seminal vesicles of the male grass goby, *Zosterisessor ophiocephalus* (Teleostei, Gobiidae). *Zoomorphology*, 111, 239–248.

Langhoffer, A. (1904): Popis riba koje su dospjele Narodnom zoološkom muzeju u Zagrebu do konca 1900. *Glasnik Hrvat. Nar. dr. Zagreb*, 16, 148–169.

Lipej, L. & J. Dulčić (2004): The current status of Adriatic fish biodiversity. In: Griffiths, H. I., B. Kryštufek & J. M. Reed (eds.): *Balkan Biodiversity. Pattern and process in the European Hotspot*. Kluwer, Dordrecht, p. 291–306.

Lipej, L., M. Orlando Bonaca & M. Šiško (2003): Coastal fish diversity in three marine protected areas and one unprotected area in the Gulf of Trieste (Northern Adriatic). *P.S.Z.N.I.: Mar. Ecol.*, 24(4), 1–15.

Lugli, M. & P. Torricelli (1999): Prespawning sound production in Mediterranean sand gobies. *J. Fish Biol.*, 54, 691–694.

Malavasi, S., J. Coppola, F. Pranovi, A. Granzotto, A. Franco & P. Torricelli (2002): Habitat riproduttivo di *Zosterisessor ophiocephalus* Pall. (Pisces, Gobiidae) in Laguna di Venezia e osservazioni sulle caratteristiche dei riproduttori. *Lavori Soc. Ven. Sci. nat.*, 27, 47–56.

Malavasi, S., P. Torricelli, M. Lugli, F. Pranovi & P. Mainardi (2003): Male courtship sounds in a teleost with alternative reproductive tactics, the grass goby, *Zosterisessor ophiocephalus*. *Env. Biol. Fish.*, 66, 231–236.

Marchesan, M., D. Ota & E. A. Ferrero (2000): The role of mechanical stimulation during breeding in the grass goby *Zosterisessor ophiocephalus* (Teleostei: Gobiidae). *Ital. J. Zool.*, 67, 25–30.

Marconato, A., M. B. Rasotto & C. Mazzoldi (1996): On the mechanism of sperm release in three gobiid fishes (Teleostei: Gobiidae). *Env. Biol. Fish.*, 46, 321–327.

Marcuzzi, G. (1972): Le collezioni dell'istituto di Biologia Marina di Rovigno conservate presso la Stazione Idrobiologica di Chioggia. *Mem. Acad. Patavina Sci. Lett. Art.*, 84(2), 169–219.

Martens, G. (1838): Reise nach Venedig. Erste Anhang. Fauna Veneta. Ulm, Stettin'schen Buchhandlung, p. 373–538.

Marzano, F. N. & G. Gandolfi (2000): A first description of an additional phosphoglucumutase locus in *Knipowitschia panizzae* (Teleostei, Gobiidae) from Italian

lagoons. *Ital. J. Zool.*, 67, 277–279.

Marzano, F. N. & G. Gandolfi (2001): Active cannibalism among adults of *Knipowitschia panizzae* (Pisces Gobiidae) induced by starvation and reproduction. *Ethol. Ecol. Evol.*, 13, 385–391.

Mazzoldi, C. & M. B. Rasotto (2001): Extended breeding season in the marbled goby, *Pomatoschistus marmoratus* (Teleostei: Gobiidae), in the Venetian Lagoon. *Env. Biol. Fish.*, 61, 175–183.

Mazzoldi, C. & M. B. Rasotto (2002): Alternative male mating tactics in *Gobius niger*. *J. Fish Biol.*, 61, 157–172.

Mazzoldi, C., M. Scaggiante, E. Ambrosin & M. B. Rasotto (2000): Mating system and alternative male mating tactics in the grass goby *Zosterisessor ophiocephalus* (Teleostei: Gobiidae). *Mar. Biol.*, 137, 1041–1048.

Mazzoldi, C., C. Polttronieri & M. B. Rasotto (2002): Egg size variability and mating system in the marbled goby *Pomatoschistus marmoratus* (Pisces: Gobiidae). *Mar. Eco. Prog. Ser.*, 233, 231–239.

McKay, S. I. & P. J. Miller (1997): The affinities of European sand gobies (Teleostei: Gobiidae). *J. Nat. Hist.*, 31, 1457–1482.

Miller, P. J. (1967): The systematic status of the European gobiid fish *Cabotichtys schmidtii* (De Buen) and *Gobius asoi* De Buen with new record from the Adriatic Sea. *Ann. Mus. Civ. Stor. Nat. Genova*, 77, 227–236.

Miller, P. J. (1969): Systematics and biology of the leopard spotted goby, *Gobius ephippiatus* (Teleostei: Gobiidae), with description of a new genus and notes on the identity of *Gobius macrolepis* Kolombatović. *J. Mar. Biol. Ass. U. K.*, 49, 831–855.

Miller, P. J. (1971): A revision of the Mediterranean gobiid genus *Chromogobius* (Teleostei – Perciformes). *J. Zool. Lond.*, 164, 305–334.

Miller, P. J. (1972a): The identity of *Gobius affinis* Kolombatović, with notes on the systematics and biology of *Pomatoschistus pictus* (Malm) (Pisces: Gobiidae). *Ann. Mus. Civ. Stor. Nat. Genova*, 79, 53–88.

Miller, P. J. (1972b): Generic status and redescription of the Mediterranean fish *Gobius liechtensteini* Kolombatović, 1891 (Teleostei: Gobiidae), and its affinities with certain American and Indo-Pacific gobies. *J. Nat. Hist.*, 6, 395–407.

Miller, P. J. (1972c): Gobiid fishes of the Caspian genus *Knipowitschia* from the Adriatic Sea. *J. Mar. Biol. Ass. U. K.*, 52, 145–160.

Miller, P. J. (1973a): Gobiidae. In: Hureau, J. C. & Th. Monod (eds): *Check-List of the Fishes of the North-Eastern Atlantic and of the Mediterranean (CLOFAM)*. Vol. 1. UNESCO, Paris, 525 pp.

Miller, P. J., (1973b): The species of *Pseudaphya* (Teleostei: Gobiidae) and the evolution of aplyiine gobies. *J. Fish Biol.*, 5, 353–365.

Miller, P. J. (1977): Gobies from Rhodes and the systematic features of *Zebrus zebrus* (Teleostei: Gobiidae). *Zool. J. Linn. Soc.*, 60, 339–362.

- Miller, P. J. (1982):** A new *Pomatoschistus* from the Mediterranean, and redescription of *P. tortonesei* Miller, 1968. *Senckenb. Biol.*, 62(1), 5–19.
- Miller, P. J. (1986):** Gobiidae. In: Whitehead, P. J. P., M.-L. Bauchot, J.-C. Hureau, J. Nielsen & E. Tortonese (eds): *Fishes of the North-eastern Atlantic and the Mediterranean*. Vol. 3. UNESCO, Paris.
- Miller, P. J. (1992):** A new species of *Didogobius* (Teleostei: Gobiidae) from the Adriatic Sea. *J. Nat. Hist.*, 26, 1413–1419.
- Miller, P. J. & E. Tortonese (1968):** Distribution and systematics of the gobiid fish *Odondebuenia balearica* (Pellegrin Fage). *Ann. Mus. Civ. Stor. Nat.*, 77, 342–359.
- Miller, P. J. & M. Y. El-Tawil (1974):** A multidisciplinary approach to a new species of *Gobius* (Teleostei: Gobiidae) from southern Cornwall. *J. Zool. Lond.*, 174, 539–574.
- Mrakovčić, M., D. Schneider & M. Kerovec (1994):** Freshwater gobies of Croatia. *Period. Biol.*, 96, 441–443.
- Mušin, D. (1989):** Ihtiološka zbirka Prirodoslovnog muzeja Biološkog zavoda Dubrovnik. *Zbornik Matice srpske za prirodne nauke*, 76, 137–168.
- Naccari, F. L. (1822):** Ittiologia Adriatica, ossia Catalogo dei pesci del golfo e laguna di Venezia. *Giornale di Fisica-chimica, storia naturale, medicina ed arti, dei professori Pietro Confighlahci e Gaspare Brugnattelli*. Decade II, tomo V. Pavia, p. 327–340.
- Nardo, G. D. (1827):** Prodomus observationum et disquisitionum Adriaticae ichthyologiae. *Diarii Physices, Chemiae et Hist. Nat.*, 10, 6–23.
- Nardo, G. D. (1860):** Prospetti sistematici degli animali delle provincie Venete e del mare Adriatico e distinzione delle specie in gruppi relativi alla loro geografia fisica ed all' interesse economico-statistico che presentano. *Atti del R. Istituto Veneto di scienze lettere ed arti*, Tomo IV, Serie III: 969–980, 1035–1076 et Tomo V, Serie III: 599–611, 785–819, 885–910.
- Ninni, A. P. (1882):** Catalogo dei ghiozzi (Gobiina) osservati nell' Adriatico e nelle acque dolci del Veneto. *Atti Soc. natur. Modena*, 3(1), 221–226.
- Ninni, A. P. (1883):** Nuova specie di *Gobius*. *Atti Soc. venet.-trent. Sci. Nat. Padova*, 8, 276–279.
- Ninni, E. (1912):** Catalogo del pesci del mare Adriatico. C. Bertotti, Venezia.
- Ninni, E. (1938):** I *Gobius* dei mai e delle acque interne d'Italia. *Mem. Comm. Talassogr. Ital.*, 242, 1–169.
- Nocita, A. & S. Vanni (1997):** Cataloghi del Museo di Storia Naturale dell' Università di Firenze – sezione di Zoologia "La Specola". XVII. Actinopterygii Perciformes: Eleotridae e Gobiidae. *Atti. Soc. tosc. Sci. nat.* B, 104, 61–69.
- Novosel, M., T. Bakran-Petricioli, A. Požar-Domac, P. Kružić & I. Radić (2002):** The benthos of the northern part of the Velebit Channel (Adriatic Sea, Croatia). *Nat. Croat.*, 11(4), 387–409.
- Onofri, I. (1983):** Ribe (Pisces) Prirodoslovnog muzeja u Splitu. *Zb. Mat. srp. za prir. nauke*, 64, 23–50.
- Orepić, N., J. Vidmar, E. Zahtila & D. Zavodnik (1997):** A marine benthos survey in the lakes of the National park Mljet (Adriatic Sea). *Period. Biol.*, 99, 229–245.
- Ota, D. & F. Lahnsteiner (1996):** Retinal vascularization in the grass goby, *Zosterisessor ophiocephalus*: a scanning electron-microscopic study of vascular corrosion casts. *Env. Biol. Fish.*, 45, 319–324.
- Ota, D., M. Francese & E. A. Ferrero (1996):** Feeding in the grass goby (*Zosterisessor ophiocephalus*, Teleostei, Gobiidae) under different light intensities: a behavioural and morphological study. *Boll. Zool. Suppl.*, 61, p. 36.
- Ota, D., M. Francese & E. A. Ferrero (1999):** Vision in the grass goby, *Zosterisessor ophiocephalus* (Teleostei: Gobiidae): a morphological and behavioural study. *Ital. J. Zool.*, 66, 125–139.
- Pallaoro, A. (2001):** Promjene kao posljedice ribolova i zagađenja. *Hrvatska vodoprivreda*, 104, 54–59.
- Pallaoro, A. & I. Jardaš (1996):** Ichthyological collection of the Institute of Oceanography and Fisheries in Split (Croatia). *Nat. Croat.*, 5(3), 177–219.
- Pallaoro, A. & M. Kovačić (2000):** *Vanneaugobius dollfusii* Brownell, 1978 a rare fish new to the Adriatic Sea. *J. Fish Biol.*, 57, 255–257.
- Patzner, R. A., M. Seiwald, S. Angerer, E. A. Ferrero & P. G. Giulianini (1991):** Genital System and Reproductive Cycle of the Male Grass Goby, *Zosterisessor ophiocephalus* (Teleostei, Gobiidae) in the Northern Adriatic Sea. *Zool. Anz.*, 226(5/6), 205–219.
- Perugia, A. (1866):** Catalogo dei Pesci dell' Adriatico nei cenni intitolati: Civico Museo Ferdinando Massimiliano in Triest. Continuazione dei cenni storici pubblicati nell' anno 1863, p. 1–21.
- Perugia, A. (1881):** Elenco sistematico degli animali del Mare Adriatico. Ulrico Hoepli Editore, Milano.
- Plučar, E. (1846):** Der Fischplatz zu Triest oder Aufzählung und populäre Beschreibung der demselben aus den adriatischen Golfe zugeführten Fische und andere essbaren Meerprodukte nebst Andeutung ihrer Zubereitung als Speise. Ernst Börner, Triest.
- Quignard, J. P. & J. A. Tomasini (2000):** Mediterranean fish biodiversity. *Biol. Mar. Med.*, 7, 1–66.
- Rasotto, M. B. & C. Mazzoldi (2002):** Male traits associated with alternative reproductive tactics in *Gobius niger*. *J. Fish Biol.*, 61, 173–184.
- Scaggiante, M., C. Mazzoldi, C. W. Peterson & M. B. Rasotto (1999):** Sperm competition and mode of fertilization in the grass goby *Zosterisessor ophiocephalus* (Teleostei: Gobiidae). *J. Exp. Zool.*, 283, 81–90.
- Seiwald, M. & R. A. Patzner (1989):** Histological, fine-structural and histochemical differences in the testicular glands of gobiid and blennioid fishes. *J. Fish Biol.*, 35, 631–640.
- Shultz, G. (1975):** Beobachtungen über Vorkommen und Lebensweise von *Thorogobius ephippiatus* (Lowe, 1839) (Pisces) in der Nord- und Mitteladria. *Ann. Nathist. Mus. Wien*, 79, 183–192.

- Simonović, P. (1999):** Phylogenetic relationship of Ponto-caspian gobies and their relationship to the Atlantic-Mediterranean Gobiinae. *J. Fish Biol.*, 54, 533–555.
- Simonović, P., V. P. Nikolić & K. E. Skora (1996):** Vertebral number in Ponto-Caspian gobies: phylogenetic relevance. *J. Fish Biol.*, 49, 1027–1029.
- Sorice, M. & V. Caputo (1999):** Genetic variation in seven goby species (Perciformes: Gobiidae) assessed by electrophoresis and taxonomic inference. *Mar. Biol.*, 134, 327–333.
- Stefanni, S. (2000):** First record of the Norway goby in the Adriatic Sea. *J. Fish Biol.*, 57, 828–830.
- Stefanni, S., E. S. Gysels, F. A. M. Volckaert & P. J. Miller (2003):** Allozyme variation and genetic divergence in the sand goby, *Pomatoschistus minutus* (Teleostei: Gobiidae). *J. Mar. Biol. Ass. U. K.*, 83, 1143–1149.
- Steindachner, F. (1861):** Beiträge zur Kenntniss der *Gobioiden*. *Sber. Akad. Wiss. Wien*, 61, 283–292.
- Steindachner, F. (1863):** Über eine neue *Gobius*-Art aus dem adriatischen Meere. *Arch. Zool. Anat. Fisiol.*, 2, 341–342.
- Steindachner, F. (1870):** Ichthyologische Notizien (X.). *Sber. Akad. Wiss. Wien*, 61, 622–642.
- Steindachner, F. (1883):** Beiträge zur Kenntniss der Fische der Adria. *Anz. Akad. Wiss. Wien*, 20, 212–214.
- Steindachner, F. & J. Kolombatović (1884):** Beiträge zur Kenntniss der Fische der Adria. *Sber. Akad. Wiss. Wien*, 88, 1193–1202.
- Stossich, A. (1869):** Elenco sistematico degli animali del Mare Adriatico riuniti nella separate divisione della fauna adriatica del Museo. *Atti Mus. Stor. nat. Trieste*, 5, 9–34.
- Stossich, M. (1880):** Prospetto della fauna del Mare Adriatico. *Boll. Soc. adr. Sci. nat. Trieste*, 5, 18–71.
- Sucker, L. (1895):** Die Fische, nebst den essenbaren Wirbellosen Thieren der Adria und ihre Zubereitung. Verlag von F. H. Schimpff, Triest, p. 1–179.
- Šoljan, T. (1948):** Ribe Jadrana. Flora i fauna Jadrana 1. Institut za oceanografiju i ribarstvo. Nakladni zavod Hrvatske, Zagreb.
- Šoljan, T. (1965):** Ribe Jadrana (Pisces mari Adriatici). Treće, prerađeno i dopunjeno izdanje. Zavod za izdavanje udžbenika SR Srbije, Beograd.
- Špan, A., B. Antolić, A. Šimunović, I. Grubelić & S. Jukić (1996):** Ecological study of gas fields in the northern Adriatic. 12. Ecological features of benthic community. *Acta Adriat.*, 37(1/2), 161–194.
- Štefčić, Z. (1977):** Lista glavoča iz voda Jugoslavije. *Bio-sistematika*, 3(1), 99–110.
- Torricelli, P., S. Malvasi, N. Novarini, F. Pranovi & D. Mainardi (2000):** Elongation of fin rays in parental males of *Zosterisessor ophiocephalus* (Pisces, Gobiidae). *Env. Biol. Fish.*, 58, 105–108.
- Tortonese, E. (1963):** Catalogo dei tipi di pesci del Museo Civico di Storia Naturale di Genova (parte III). *Ann. Mus. Civ. Stor. Nat. Giacomo Doria*, 73, 333–350.
- Tortonese, E. (1975):** Osteichthyes (Pesci ossei), Parte seconda. Fauna d'Italia. Vol. 11. Edizioni Calderini, Bologna, 636 pp.
- Trois, E. F. (1875):** Prospetto sistematico dei Pesci dell'Adriatico e Catalogo della Collezione Ittiologica del R. Istituto Veneto. *Atti R. Istituto Veneto*, 1, 3–55.
- Turk, R., M. Orlando Bonaca, T. Makovec, A. Vuković & L. Lipej (2002):** A topographical survey of habitat types in the area characterized by seagrass meadow of *Posidonia oceanica* in the southern part of the Gulf of Triest (northern Adriatic). *Annales Ser. Hist. Nat.*, 12(2), 191–202.
- Ungaro, N., N. Casavola, G. Marano & E. Rizzi (1994):** "Bianchetto" and "rossetto" fry fisheries in the Manfredonia Gulf: effort and catch composition. *Oebalia*, 20, 99–106.
- Usić, U. (2003.):** La biodiversità nell'alto Adriatico: Un confronto tra presente e passato attraverso le collezioni museali. Tesi di Laurea. Facoltà di Scienze dell'Università di Padova, Padova.
- Verga, D. (1841):** Descrizione di un *Gobius* frequente nelle lagune di Comacchio. *Atti 3ª Riunione Scienziati Italiani*, p. 379.
- Vinciguerra, D. (1883):** Risultati ittiologici della crociera del "Violante". *Ann. Mus. Civ. Stor. Nat. Genova*, 18, 465–590.
- Vuković, T. & B. Ivanović (1971):** Slatkovodne ribe Jugoslavije. Zemaljski muzej BiH, Sarajevo.
- Zander, C. D. & H. Jelinek (1976):** Zur demersen Fischfauna im Bereich der Grotte von Banjole (Rovinj/YU) mit Beschreibung von *Spelegobius trigloides* n. gen. n. sp. (Gobiidae, Perciformes), *Mitt. Hamb. Zool. Mus. Inst.*, 73, 265–280.
- Zavodnik, D. (1971):** Contribution to the dynamics of benthic communities in the region of Rovinj (Northern Adriatic). *Thalassia Jugosl.*, 7(2), 447–514.
- Zavodnik, D. & N. Zavodnik (1986):** Biološka valorizacija zaljeva Raša. III. Benthos. *Pomorski zbornik*, 24, 535–554.
- Zavodnik, D. & D. Crnković (1992):** Prilozi morskoj flori I fauni lošinskje otočne skupine VIII. Ribe (*Pisces, sensu stricto*). *Otočki ljetopis Cres-Lošinj*, 8, 265–272.
- Zavodnik, D. & M. Kovačić (2000):** Index of marine fauna in the Rijeka Bay (Adriatic Sea, Croatia). *Nat. Croat.*, 9(4), 297–379.
- Zei, M. (1942):** Biologische Ergebnisse einiger Forschungsreisen in der Adria. *Arch. Oceanogr. Limnol.*, Venezia, 2(2–3), 171–197.
- Zei, M. (1949):** Raziskovanje s travlom na ribolovnom području vzhodnega Jadrana. *Razprave JAZU*, 4, 89–119.
- Županović, Š. (1961):** Kvantitativno-kvalitativna analiza ribljih naselja kanala srednjeg Jadrana. *Acta Adriat.*, 9(3), 1–151.
- Županović, Š. & F. Grubišić (1958):** Ribolovna efikasnost vuče u eksperimentima sa strugarima. *Acta Adriat.*, 8(12), 1–27.
- Županović, Š. & I. Jardaš (1989):** Fauna i flora Jadrana, Jabučka kotlina, 2. Institut za oceanografiju i ribarstvo – Split, Fauna et flora Adriatica vol. IV. Split, Logos.

short scientific article
received: 2005-08-23

UDC 597.5591.9(262)

FIRST RECORD OF THE ZEBRA GOBY, *ZEBRUS ZEBRUS* (PISCES: GOBIIDAE), IN THE IONIAN SEA

Marcelo KOVAČIĆ

Natural History Museum Rijeka, Lorenzov prolaz 1, HR-51000 Rijeka
E-mail: Marcelo.Kovacic@public.srce.hr

Simona BUSSOTTI & Paolo GUIDETTI

Laboratory of Zoology and Marine Biology, DiSTeBA, University of Lecce, Via Provinciale Monteroni, I-73100 Lecce, Italy

ABSTRACT

*Two specimens of the zebra goby, *Zebrus zebrus* (Risso, 1826), were collected in the Ionian Sea. The present finding is the first record for the Ionian Sea and a proof of a continuous distribution of this species between the western and eastern Mediterranean and the Adriatic Seas.*

Key words: *Zebrus zebrus*, first record, morphology, ecology, Ionian Sea

PRIMA SEGNALEZIONE DI GHIOZZETTO ZEBRA *ZEBRUS ZEBRUS* (PISCES: GOBIIDAE) NEL MAR IONIO

SINTESI

*Due esemplari di ghiozzetto zebra *Zebrus zebrus* (Risso, 1826) sono stati raccolti nel mar Ionio. Tale ritrovamento rappresenta la prima segnalazione per il mar Ionio e conferma la distribuzione continua di tale specie dal Mediterraneo occidentale a quello orientale e al mare Adriatico.*

Parole chiave: *Zebrus zebrus*, prima segnalazione, morfologia, ecologia, mar Ionio

INTRODUCTION

During the last decade, the use of SCUBA techniques has improved knowledge of geographical range and diversity of small gobies in the Mediterranean Sea. Most of these records, however, are from the western Mediterranean (Ahnelt *et al.*, 1994; Stefanni & Mazzoldi, 1999; Herler & Patzner, 2002 and ref. therein) and the Adriatic Seas (Kovačić, 2001, 2002; Herler & Kovačić, 2002; Herler & Patzner, 2002 and ref. therein). The diversity of small gobiid fauna of the other sectors of the Mediterranean is relatively unknown. The aim of this paper is to present the first record of the zebra goby, *Zebrus zebrus* (Risso, 1826), in the Ionian Sea.

MATERIAL AND METHODS

One juvenile of unidentified sex, 13.6±3.2 mm, PC-ZZ1, Torre Inserraglio (SE Italy, SW Apulia, Ionian Sea), 8 November 2002; one juvenile of unidentified sex, 15.6 mm SL with damaged C, PC-ZZ2, Torre Inserraglio (SE Italy, SW Apulia, Ionian Sea), 11 December 2002 (Figs. 1, 2). The two specimens were found in benthic samples taken with a suction sampler. The specimens are deposited at the Museum of Marine Biology in Porto Cesareo. Identification was carried out according to Miller (1986).

Meristic methods as in Miller (1988). Meristic abbreviations: A, anal fin; C, caudal fin; D1, D2, first and second dorsal fin; P, pectoral fin; V, pelvic disc; LL, scales in lateral series; TR, scales in transverse series. Terminology of lateral-line system follows Sanzo (1911) and Miller (1986).

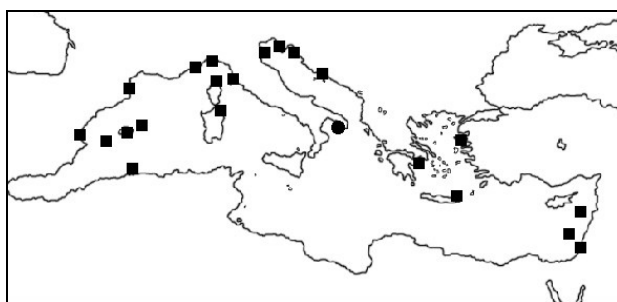


Fig. 1: Map of the past records and the records reported in this paper of *Zebrus zebrus* in the Mediterranean Sea; (■) past records, (●) present record.

Sl. 1: Zemljevid z označenimi lokalitetami v Sredozemskem morju, kjer je bil zebrasti glavač *Zebrus zebrus* odkrit v preteklosti in kot je njegovo pojavljanje opisano v tem članku; (■) pretekli zapisi, (●) zapis v tem članku.

RESULTS

Morphology

The specimens are characterized by: anterior nostril short, tubular, with tentacle from inner part of rim. Branchiostegal membrane attached to entire side of isthmus. Fins: D1 VI; D2 I/11; A I/9; C 16 branched rays, 14 articulated rays; P 17-18 (both sides: 17 and 17: 1, 17 and 18: 1); V I/5+I/5. Damaged fins did not influence the counting, except C branched rays in specimen PC-ZZ2. P uppermost rays free from membrane; V complete, with anterior transverse membrane. Body with ctenoid scales, LL 31 and 33, TR 11. Head, predorsal area and breast naked. Colour preserved: body fawn, 8 vertical dark bars. Head with three transverse bars spreading from each eye over cheek and snout. Predorsal area and operculum pigmented. Underside of head and breast pigmented. D1 with two longitudinal bands; D2 with three to four longitudinal bands; C with vertical dark strips, the most intensive strip along origin, the others poorly visible; P with vertical dark strip along origin, the rest of fin colourless; A and V colourless, except dots along A base. Head with anterior and posterior oculoscapular, and preopercular canals, with pores σ , λ , κ , ω , α , β , ρ , ρ^1 , ρ^2 , and γ , δ , ε respectively. Rows and number of sensory papillae as follows: *preorbital*: r (3-4), s^1 (1-2), s^2 (1-2), s^3 (1-2), c^1 (2), c^2 (2), c_1 (2-4), c_2 (2); *suborbital*: 1 (4-5), 2 (5), 3 (2-4), 4 (3-4), 5s (2-3), 5i (2-3), 6s (3), 6i (3-4), 7 (1-2), 8 (5-6), 9 (13); *preoperculo-mandibular*: e (24-26), i (14-15), f (3); *oculoscapular*: x^1 (5), x^2 (3), tr (2), z (3), q (2), y (1), as^1 (6), as^2 (8), la^1 (2), la^2 (2); *opercular*: ot (12), os (4), oi (3-4); *anterior dorsal*: n (4-6), g (6), o (6), m (3), h (8). Oculoscapular rows x^1 , x^2 , y, as^1 , as^2 , as^3 , la^1 , la^2 and anterior dorsal rows g, o, m, h (specimen PC-ZZ1) and oculoscapular rows tr, la^3 and suborbital row d (specimen PC-ZZ2) were not visible probably due to skin damage. Seven transverse suborbital rows of sensory papillae; last row represented by a single papilla near pore α ; four before, two below longitudinal row b. Row b anteriorly beginning before rear border of the eye. Suborbital row d continuous.

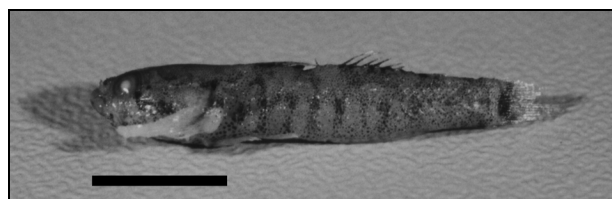


Fig. 2: *Zebrus zebrus*, juvenile of unidentified sex, 15.6 mm SL collected at Torre Inserraglio, SE Italy (Ionian Sea), 11 December 2002. Scale = 5 mm.

Sl. 2: *Zebrus zebrus*, mladostni osebek neugotovljenega spola, 15,6 mm SL, ujet 11. decembra 2002 v bližini kraja Torre Inserraglio, JV Italija (Jonsko morje). Merilo = 5 mm.

Ecological distribution

The two specimens of *Z. zebrus* were collected in shallow (5-7 m depth) sub-vertical rocky substrates exposed to wave action and characterised by the presence of boulders of various size with flourishing benthic cover. In particular, the specimen PC-ZZ2 was collected in a rocky reef dominated by filamentous brown algae (e.g. *Ectocarpus* and *Sphacelaria* sp.), filamentous green algae (e.g. *Bryopsis*, *Cladophora* and *Chaetomorpha* spp.), encrusting calcified red algae (e.g. *Lithophyllum frondosum*, *L. incrustans*) and the sponge *Crambe crambe*. The specimen PC-ZZ1, instead, was collected in rocky reef affected by discharges of an outfall. Red algae of the genera *Pterocladia* and *Gelidium*, and the brown algae *Colpomenia sinuosa*, in this case, accounted for a significant fraction of the benthic cover (see Terlizzi *et al.*, 2002 for details).

DISCUSSION

The present record of *Z. zebrus* for the Ionian Sea suggests that the distribution of this species is fairly continuous along the Mediterranean coasts. Previous records came from the north-western part of the basin, the Adriatic and the Aegean Seas, and the Levantine basin (Fig. 1) (Miller, 1977; Ahnelt, 1990; Ahnelt & Patzner, 1996; Kovačić, 1997).

The specimens collected in the Ionian Sea generally correspond in body morphology, head and fins, squa-

mation, colouration, and in lateral line system to populations of *Z. zebrus* from the other parts of Mediterranean basin. The present specimens differ from species description (Miller, 1977, 1986) in the lower number of sensory papillae in rows. However, the collected specimens were juveniles. The increase in the number of sensory papillae in rows during juvenile growth is known for some gobiid species (Kovačić, 2004).

As regards the habitat occupation, it has to be noted that *Z. zebrus* is reported to live in a large spectrum of habitats from about 0 to 10 m depth, like seagrasses and/or in estuarine habitats (Tortonese, 1975), various rocky habitats (e.g. boulders, holes, cavities, small caves, bedrock, sands with individual stones, in some cases in association with sea urchins; Ahnelt & Patzner, 1996; Kovačić, 1997; Patzner, 1999a, b), and intertidal pools (Ahnelt, 1990; Nieto & Alberto, 1992; Miller, 1977). The evidences reported here and the literature data suggest that *Z. zebrus* is able to thrive in many habitat types at shallow depth (approximately down to 10 m). These relatively scarce habitat preferences and the increasing number of records year by year lead to conclude that *Z. zebrus* is likely to be far more common in the Mediterranean Sea than currently thought.

ACKNOWLEDGEMENTS

Many thanks are due to A. L. Delos for having kindly provided us with the *Zebrus zebrus* specimens.

PRVI PODATEK O ZEBRASTEM GLAVAČU *ZEBRUS ZEBRUS* (PISCES: GOBIIDAE) IZ JONSKEGA MORJA

Marcelo KOVAČIĆ

Prirodoslovni muzej Rijeka, Lorenzov prolaz 1, HR-51000 Rijeka, CROATIA.

E-mail: Marcelo.Kovacic@public.srce.hr

Simona BUSSOTTI & Paolo GUIDETTI

Laboratory of Zoology and Marine Biology, DiSTeBA, University of Lecce, Via Provinciale Monteroni, I-73100 Lecce, Italy

POVZETEK

Avtorji poročajo o prvem odkritju zebrastega glavača *Zebrus zebrus* v Jonskem morju. V vodah jugozahodne Apulije (Jonsko morje) sta bila na plitvi kamniti podlagi, prekriti z makroalgami, ujeta dva primerka zebrastega glavača. Glede na podatke, objavljene v tem članku, in podatke iz literature je mogoče sklepati, da ta vrsta lahko uspeva v plitvi vodi mnogih habitatnih tipov (do približno 10 m). Avtorji navajajo meristične podatke o obeh primerkih zebrastega glavača. Sicer pa se osebk, ujeti v Jonskem morju, morfološko in barvno na splošno ujemajo s populacijami te vrste iz drugih delov Sredozemskega morja, najnovejše odkritje pa je dokaz o kontinuirani razširjenosti te vrste med zahodnim in vzhodnim Sredozemskim morjem in Jadranom.

Ključne besede: *Zebrus zebrus*, prvi podatek, morfologija, ekologija, Jonsko morje

REFERENCES

- Ahnelt, H. (1990):** *Chromogobius quadrivittatus*, *Chromogobius zebratus* und *Zebrus zebrus* (Pisces, Gobiidae): Erstnachweise für Korsika (Frankreich) und Sardinien (Italien). Ann. Nathist. Mus. Wien, 91B, 27–41.
- Ahnelt, H., P. J. Miller & R. A. Patzner (1994):** Systematics and distribution of two rare Mediterranean gobies, *Corcyrogobius liechtensteini* (Kolombatović, 1891) and *Odondebuenia balearica* (Pellegrin and Fage, 1907) (Teleostei: Gobiidae). Cybium, 18, 169–176.
- Ahnelt, H. & R. A. Patzner (1996):** Kryptobenthische Meergrundeln von den Balearen (Westliches Mittelmeer) mit Anmerkungen zum Unterartstatus von *Chromogobius zebratus levanticus* Miller, 1971. Ann. Nathist. Mus. Wien, 98B, 529–544.
- Herler, J. & M. Kovačić (2002):** *Lebetus guiletti* (Teleostei: Gobiidae) in the northern Adriatic Sea: First record and details in the species' morphology. Annales, Ser. hist. nat., 12(2), 177–188.
- Herler, J. & R. A. Patzner (2002):** New records of *Didogobius splechnai* (Gobiidae) from the Tyrrhenian and Northern Adriatic Sea. Cybium, 26, 153–155.
- Kovačić, M. (1997):** Cryptobenthic gobies and clingfishes in the Kvarner area, Adriatic Sea. Nat. Croat., 6, 423–435.
- Kovačić, M. (2001):** The Kvarner population of *Gobius couchi* (Teleostei, Gobiidae), a fish new to the Adriatic fauna. Nat. Croat., 10, 1–10.
- Kovačić, M. (2002):** A northern Adriatic population of *Buenia affinis* (Gobiidae). Cybium, 26, 197–201.
- Kovačić, M. (2004):** Unusual morphological and ecological characteristics of hyperbenthic juveniles of *Gobius cruentatus*. J. Fish Biol., 65, 545–558.
- Miller, P. J. (1977):** Gobies from Rhodes and the systematic features of *Zebrus zebrus* (Teleostei: Gobiidae). Zool. J. Lin. Soc., 60, 339–362.
- Miller, P. J. (1986):** Gobiidae. In: Whitehead, P. J. P., M.-L. Bauchot, J.-C. Hureau, J. Nielsen & E. Tortonese (eds.): Fishes of the North-eastern Atlantic and the Mediterranean. Vol. III. UNESCO, Paris, p. 1019–1085.
- Miller, P. J. (1988):** New species of *Corcyrogobius*, *Thorogobius* and *Wheelerigobius* from West Africa (Teleostei: Gobiidae). J. Nat. Hist., 22, 1245–1262.
- Nieto, P. & L. J. Alberto (1992):** The presence of *Zebrus zebrus* (Risso, 1826) (Gobiidae) on the Atlantic coast of Spain. Cybium, 16, 137–144.
- Patzner, R. A. (1999a):** Sea urchins as a hiding-place for juvenile benthic teleosts (Gobiidae and Gobiessocidae) in the Mediterranean Sea. Cybium, 23, 93–97.
- Patzner, R. A. (1999b):** Habitat utilization and depth distribution of small cryptobenthic fishes (Blenniidae, Gobiessocidae, Gobiidae, Tripterygiidae) in Ibiza (western Mediterranean Sea). Environ. Biol. Fish., 55, 207–214.
- Sanzo, L. (1911):** Distribuzione delle papille cutanee (organi ciatiforme) e suo valore sistematico nei Gobi. Mitt. Zool. Stat. Neapel, 20, 249–328.
- Stefanni, S. & C. Mazzoldi (1999):** The presence of the Couch's goby in the Mediterranean Sea. J. Fish Biol., 54, 1128–1131.
- Terlizzi, A., S. Fraschetti, P. Guidetti & F. Boero (2002):** The effects of sewage discharge on shallow hard substrate sessile assemblages. Mar. Poll. Bull., 44, 544–550.
- Tortonese, E. (1975):** Osteichthyes (Pesci ossei). Parte seconda. Fauna d'Italia, Vol. 11. Calderini, Bologna.

original scientific article
received: 2005-01-24

UDC 591.9:597.3 (262.53)

PHOTOGRAPHIC EVIDENCE OF THE OCCURRENCE OF BRAMBLE SHARK, *ECHINORHINUS BRUCUS* (BONNATERRE, 1788) (SQUALIFORMES: ECHINORHINIDAE) FROM THE SEA OF MARMARA

Hakan KABASAKAL

Ichthyological Research Society, Atatürk mahallesi, Menteşoğlu caddesi, İdil apt., No: 30/4, Ümraniye, TR-34764 İstanbul, Turkey
E-mail: hakankabasakal@hotmail.com

M. İdil Öz & S. Ünsal KARHAN

University of İstanbul, Institute of Marine Sciences and Management, Müşküle sokak, No: 1, Vefa, İstanbul, Turkey

Ziya ÇAYLARBAŞI & Umut TURAL

Ichthyological Research Society, Atatürk mahallesi, Menteşoğlu caddesi, İdil apt., No: 30/4, Ümraniye, TR-34764 İstanbul, Turkey

ABSTRACT

On October 2002, a bramble shark Echinorhinus brucus (Bonnaterre, 1788) was imaged by means of a ROV camera at a depth of 1214 m in the northern Sea of Marmara. This single recording of the bramble shark shows that E. brucus, once thought extinct in Turkish seas, still occurs in this area. E. brucus is a very rare shark species in the Mediterranean and needs immediate protection in the entire area.

Key words: *Echinorhinus brucus*, Echinorhinidae, bramble shark, Sea of Marmara, distribution

EVIDENZA FOTOGRAFICA DELLA PRESENZA DI RONCO SPINOSO *ECHINORHINUS BRUCUS* (BONNATERRE, 1788) (SQUALIFORMES: ECHINORHINIDAE) NEL MAR DI MARMARA

SINTESI

Nell'ottobre del 2002 un esemplare di ronco spinoso Echinorhinus brucus (Bonnaterre, 1788) è stato filmato nel Mar di Marmara settentrionale con l'ausilio di una telecamera per ROV, ad una profondità di 1214 metri. Quest'unica testimonianza della presenza di ronco spinoso, creduto estinto in acque turche, conferma che la specie è ancora presente nell'area. E. brucus è una specie di squalo rara in Mediterraneo e ha bisogno di venir protetta immediatamente nell'intera area.

Parole chiave: *Echinorhinus brucus*, Echinorhinidae, ronco spinoso, Mar di Marmara, distribuzione

INTRODUCTION

According to Compagno (1984), the bramble shark *Echinorhinus brucus* (Bonnaterre, 1788) (Fig. 1) is a large, sluggish bottom-dwelling shark, sometimes occurring in shallow waters but primarily a deepwater species on the continental and insular shelves and upper slopes at depths from 18 to 900 m. It is an ovoviviparous species and the number of young per litter varies from 15 to 24, with a maximum total length to about 310 cm (Compagno, 1984). Although it is captured by bottom trawls and line gear in the eastern Atlantic, especially from the North Sea to Portugal, it is relatively unimportant as a fisheries species (Compagno, 1984).

E. brucus is fairly common in the western to eastern Atlantic and in western Indian oceans (Compagno, 1984; Silas & Selveraj, 1972). Its distribution in the Mediterranean Sea includes both western and central parts of the basin (Risso, 1810; Moreau, 1881; Carus, 1889–1893; Ninni, 1912; Tortonese, 1956; Bini, 1967; McEachran & Branstetter, 1984; Bauchot, 1987; Barrull *et al.*, 1999; Hemida & Capapé, 2002; De Maddalena & Zuffa, 2003). In a recent study, De Maddalena & Zuffa (2003) summarised capture information on 24 bramble sharks, mainly in the central Mediterranean Sea, between 1798 and 2000. Although McEachran & Branstetter (1984) stated that the Mediterranean distribution of *E. brucus* includes the entire basin, Hemida & Capapé (2002) reported in their recent study that the bramble shark had been recorded only in the western Mediterranean basin and not in its eastern part.

Occurrence of the bramble shark in Turkish seas has been reported by Akşiray (1987); however, the author did not give information on the captured or examined specimens. Due to the lack of this shark species in the capture records of the last 15 years, Kabasakal (2002) concluded that *E. brucus* had probably disappeared from Turkish waters.

A single bramble shark has been recorded in the Sea of Marmara by Ninni (1923). Similarly, due to the lack of this shark in the recent ichthyological records from the Sea of Marmara (Eräzi, 1942; Kocataş *et al.*, 1993), it

has been suggested that *E. brucus* had also disappeared from Marmaric waters (Kabasakal, 2003).

In the present paper, a single recent recording of *E. brucus* in the Sea of Marmara is presented and its distribution in the Mediterranean Sea discussed.

MATERIAL AND METHODS

The video image of bramble shark was recorded by means of a Remotely Operated Vehicle (ROV) camera, operated at a depth of 1214 m in Tekirdağ trench, submarine part of the northern Anatolian fault (northern Sea of Marmara, Fig. 2). During its imaging, it was not possible to estimate the size of the specimen.

The video clip and the photographs of the bramble shark are kept in the archive of the first author at the Ichthyological Research Society (IRS). As the photographs are extracted from the video clip, their quality is very poor; however, the main diagnostic characters of *E. brucus* are clearly visible both on the film and in figures 3 and 4. Identification follows Compagno (1984), while the taxonomic nomenclature follows Bilecenoğlu *et al.* (2002).

RESULTS AND DISCUSSION

On October 2002, a bramble shark *Echinorhinus brucus* was imaged by means of a ROV camera at a depth of 1214 m in the northern Sea of Marmara (Fig. 2). The following description of the observed bramble shark is based on the specimen seen in figures 3 and 4. Body is robustly fusiforme with a wide caudal peduncle. Two small dorsal fins are located far back on the body, close to caudal fin; the beginning of the first dorsal fin is almost over the posterior portion of the pelvic fin base; the beginning of the second dorsal fin is almost over the pelvic fin tips. Pelvic fins are relatively long based and remarkably large. Pectoral fins are short. No anal fin. There is neither sub-terminal notch nor posterior notch on caudal fin, and the lower lobe is not well differentiated (Fig. 4). Body is brownish grey with lighter areas on pectoral and pelvic fins.

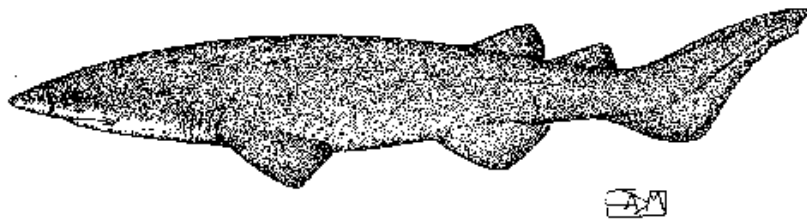


Fig. 1/Sl. 1: *Echinorhinus brucus* (Bonnaterre, 1788).
(Drawing/Risba: A. De Maddalena)

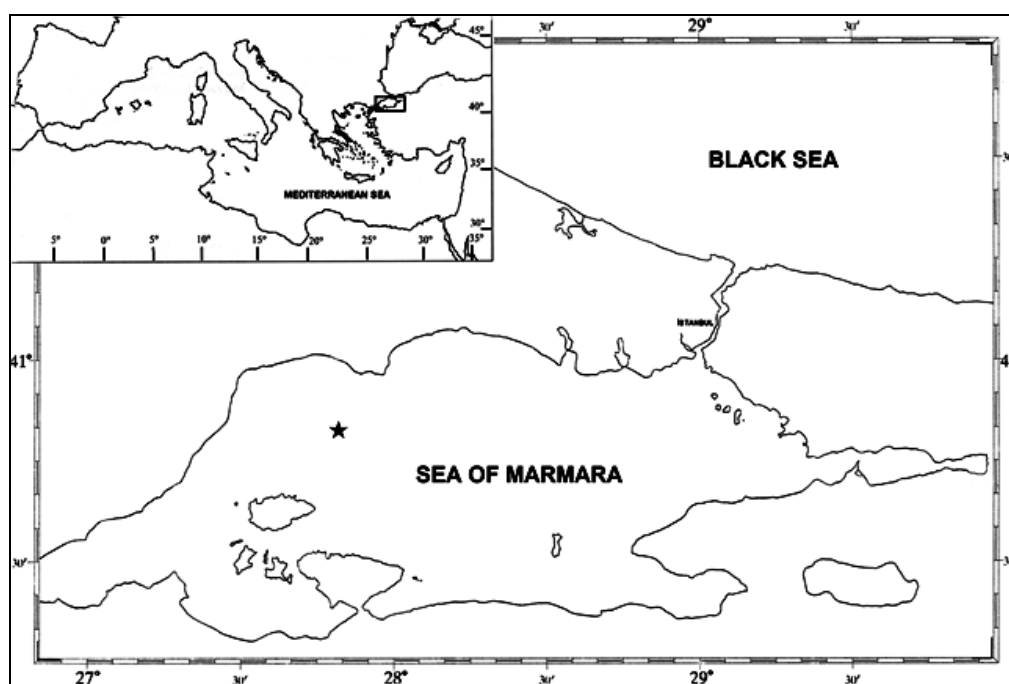


Fig. 2: Approximate location of the observation site, where the video image of the Marmaric specimen of *E. brucus* was recorded. The rectangle on the small map indicates the area of investigation. (Drawing: H. Kabasakal)

Sl. 2: Približna lokacija, na kateri je bil posnet marmarski primerek bodičastega morskega psa *E. brucus*. Pravokotnik na malem zemljevidu ponazarja raziskovano območje. (Risba: H. Kabasakal)

Among the Mediterranean sharks, *E. brucus* is a species that can be easily identified by means of its characteristic buckler-like dermal denticles and the position of dorsal fins (Moreau, 1881; Tortonese, 1956; Bini, 1967; McEachran & Branstetter, 1984; Bauchot, 1987; Hemida & Capapé, 2002). Due to the image quality, no buckler-like dermal denticles were observed on the specimen; however, owing primarily to the position of the dorsal fins, as well as to some other diagnostic characters, we were able to identify the observed specimen as *E. brucus*.

In the Mediterranean Sea, *E. brucus* was recorded for the first time by Risso (1810), based on a specimen captured off Nice in 1798. Since then, a few bramble sharks have been recorded mostly in the western Mediterranean and adjacent waters. According to Ninni (1912), *E. brucus* is an accidentally captured shark in the Adriatic Sea. Ninni (1912) reported on two bramble sharks captured in Adriatic waters; one on 5 May 1877 (reported by E. F. Trois), and one in February 1904 off Porto di Chioggia. The bramble shark reported by Trois (1876, in Tortonese, 1956) was the first record of *E. brucus* from the Adriatic Sea. For the time being, a total of 24 captures of *E. brucus* are available among historical and contemporary records, all of which come from the western and central Mediterranean Sea (De Maddalena & Zuffa, 2003). According to Hemida & Capapé (2002) *E. brucus* had probably disappeared from the



Fig. 3: Side view of the bramble shark approaching the ROV at a depth of 1214 m. The transparent core sampling tube was used as a reference for estimating the total length of the shark. (Photo: IRS archive)

Sl. 3: Pogled od strani na bodičastega morskega psa, ki se na globini 1214 m približuje kameri v daljinsko vodenem plovilu. Pri ocenjevanju celotne iztegnjene dolžine preučevanega morskega psa je bila kot primerjava uporabljena prozorna vzorčna cev plovila. (Foto: Arhiv IRS)

Mediterranean Sea. However, the capture of a bramble shark, 254 cm TOT, captured off Annaba, indicates that it still occurs off the coast of Algeria (Hemida & Capapé, 2002).

According to Bauchot (1987), *E. brucus* is distributed along the entire Aegean coast of Turkey, but is apparently absent from the Turkish Mediterranean Sea and from the Sea of Marmara. McEachran & Branstetter (1984) stated that Mediterranean distribution of *E. brucus* extends to the Anatolian coast of both the Aegean and the Mediterranean Seas, with seasonal or occasional occurrence. Due to the absence of *E. brucus* in the fishing records of the last 15 years, Kabasakal (2002, 2003) concluded that the bramble shark had probably disappeared from Turkish seas. The capture of the Marmaric bramble shark in October 2002 indicated that *E. brucus* still occurs in Turkish waters.

In the greater part of the scientific literature, the reported depth range of the bramble shark is 400 to 900 m (Tortonese, 1956; Bini, 1967; McEachran & Branstetter, 1984; Bauchot, 1987; Hemida & Capapé, 2002), while Compagno (1984) reported its depth range as 18 to 900 m. The Marmaric bramble shark has been observed at a depth of 1214 m, which exceeds the previous maximum depth record of *E. brucus*.

According to Compagno (1984), *E. brucus* can reach up to 310 cm TOT. A 258 cm long male caught before 1879 off Nice, France, on display in the Pavia Museum of Zoology, is the largest Mediterranean bramble shark known to date (De Maddalena & Zuffa, 2003). Silas & Selveraj (1972) reported on two adult males of 162 and 174 cm TOT, captured over the continental slope from 200 to 400 meters off the west coast of India (Indian Ocean). Compagno (1984) reported that females between 213 and 230 cm TOT, and males between 150 and 174 cm TOT were adults. Total length of a gravid female bramble shark, captured off the Elba Island (western Mediterranean Sea) around 1985, was estimated at 250 cm (De Maddalena & Zuffa, 2003). Recent capture of an adult female of 254 cm TOT, off Annaba (eastern coast of Algeria), was reported by Hemida & Capapé (2002). On the photographs of a Marmaric bramble shark, the pelvic region of the specimen is not clear; this is the reason why the authors could not determine its sex. As we could not estimate the size of the shark, it was not possible to make any statement whether the specimen was sexually mature.



Fig. 4: Pelvic region and the lower caudal lobe of the bramble shark. (Photo: IRS archive)

Sl. 4: Medenica in spodnja repna krpica bodičastega morskega psa. (Foto: IRS archive)

CONCLUSIONS

"In the early days of marine biology...", as originally written by Barnes & Hughes (1988), "many people predicted that the abyssal depths would be found to be lifeless..." However, owing to the invention of deep-diving submersibles or unmanned vehicles, such as ROVs, we have now the opportunity to reveal the mysteries of deep seas. The video images recorded by the ROV camera during the seismic survey of Marmaric trenches in October 2002 clearly indicated that *Echinorhinus brucus* still occurs in the Sea of Marmara, a subregion of the eastern Mediterranean. The scarcity of bramble shark captures is due to the fact that the species inhabits deep bottoms between 500 and 900 m (or 1214 m in our case), where it is not subjected to commercial fishing pressures. *E. brucus*, as reported by De Maddalena & Zuffa (2003), is very rare in the Mediterranean and needs immediate protection in the entire area.

ACKNOWLEDGMENTS

The authors wish to thank to Alessandro De Maddalena, Italian Great White Shark Data Bank, Milan, Italy, for the illustration of *Echinorhinus brucus*.

FOTOGRAFSKI DOKAZI O POJAVLJANJU BODIČASTEGA MORSKEGA PSA *ECHINORHINUS BRUCUS* (BONNATERRE, 1788) (SQUALIFORMES: ECHINORHINIDAE) V MARMARSKEM MORJU

Hakan KABASAKAL

Ichthyological Research Society, Atatürk mahallesi, Menteşoğlu caddesi, İdil apt., No: 30/4, Ümraniye, TR-34764 İstanbul, Turkey
E-mail: hakankabasakal@hotmail.com

M. İdil Öz & S. Ünsal KARHAN

University of İstanbul, Institute of Marine Sciences and Management, Müşküle sokak, No: 1, Vefa, İstanbul, Turkey

Ziya ÇAYLARBAŞI & Umut TURAL

Ichthyological Research Society, Atatürk mahallesi, Menteşoğlu caddesi, İdil apt., No: 30/4, Ümraniye, TR-34764 İstanbul, Turkey

POVZETEK

Oktobra leta 2002 je bil v Marmarskem morju na globini 1214 m s kamero ROV – kamera v daljinsko vodenem plovilu – posnet bodičasti morski pes *Echinorhinus brucus* (Bonnaterre, 1788). Ta edini posnetek te vrste dokazuje, da se *E. brucus*, o katerem je veljalo prepričanje, da je izginil iz turških morij, še vedno pojavlja v teh vodah. *E. brucus* je zelo redka vrsta morskega psa v Sredozemskem morju in ga je treba nemudoma zaščititi v celotnem območju.

Ključne besede: *Echinorhinus brucus*, Echinorhinidae, bodičasti morski pes, Marmarsko morje, razširjenost

REFERENCES

- Akşiray, F. (1987):** Türkiye Deniz Balıkları ve Tayin Anahtarı. 2nd Edition, Publications of İstanbul University, no. 3490, İstanbul, 811 pp.
- Barnes, R. S. K. & R. N. Hughes (1988):** An Introduction to Marine Ecology. Blackwell Scientific Publications, Oxford, 351 pp.
- Barrull, J., I. Mate & M. Bueno (1999):** Observaciones de tiburones (Chondrichthyes Euselachii) en aguas de Cataluña (Mediterráneo NO), con algunos aspectos generales de su ecología. Sci. gerundensis, 24, 127–151.
- Bauchot, M. –L. (1987):** Requins. In: Fischer, W., M. Schneider & M. –L. Bauchot (eds.): Fiches FAO d'identification des espèces pour les besoins de la pêche. (Révision 1). Méditerranée et mer Noire. Zone de pêche 37. Vol. II. Vertébrés. FAO, Roma, p. 767–843.
- Bilecenoglu, M., E. Taskavak, S. Mater & M. Kaya (2002):** Checklist of the marine fishes of Turkey. Zootaxa 113. Magnolia Press, Auckland, 194 pp.
- Bini, G. (1967):** Atlante dei pesci delle coste Italiane. Vol. I. Leptocardi-Ciclostomi-Selachi. Mondo Sommerso Editrice, Roma, 206 pp.
- Carus, J. V. (1889-1893):** Prodrum Faunae Mediterraneae. Vol. II. Brachiostomata, Mollusca, Tunicata, Vertebrata. E. Schweizerbart'sche Verlagshandlung, Stuttgart, 854 pp.
- Compagno, L. J. V. (1984):** FAO species catalogue. Vol. 4. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Part 1. Hexanchiformes to Lamniformes. FAO Fish. Synop., 125(4), 1–249.
- De Maddalena, A & M. Zuffa (2003):** A gravid female bramble shark, *Echinorhinus brucus* (Bonnaterre, 1788), caught off Elba Island (Italy, northern Tyrrhenian Sea). Annales Ser. hist. nat., 13(2), 167–172.
- Erazi, R. A. R. (1942):** Marine fishes found in the Sea of Marmara and in the Bosphorus. Ist. Univ., Fen Fak. Mecmuası, seri B, 7(1–2), 103–115.
- Hemida, F. & C. Capapé (2002):** Observations on a female Bramble shark, *Echinorhinus brucus* (Bonnaterre, 1788) (Chondrichthyes: Echinorhinidae), caught off the Algerian coast (southern Mediterranean). Acta Adriat., 43(1), 103–108.
- Kabasakal, H. (2002):** Elasmobranch species of the seas of Turkey. Annales Ser. hist. nat., 12(1), 15–22.
- Kabasakal, H. (2003):** Historical and contemporary records of sharks from the Sea of Marmara, Turkey. Annales Ser. hist. nat., 13(1), 1–12.
- Kocataş, A., T. Koray, M. Kaya & Ö. F. Kara (1993):** Review of the fishery resources and their environment in the Sea of Marmara. FAO, General Fisheries Council for the Mediterranean. Studies and Reviews, 64(3), 87–143.

McEachran, J. D. & S. Branstetter (1984): Squalidae. In: Whitehead, P. J. P., M. -L. Bauchot, J. -C. Hureau, J. Nielsen & E. Tortonese (eds.): Fishes of the North-eastern Atlantic and the Mediterranean., Vol. I. UNESCO, Paris, p. 128–147.

Moreau, E. (1881): Histoire naturelle des poissons de la France. Vol. II. Masson, Paris, 479 pp.

Ninni, E. (1912): Catalogo dei pesci del Mare Adriatico. Carlo Bertotti, Venezia, 271 pp.

Ninni, E. (1923): Primo contributo allo studio dei pesci e della pesca nelle acque dell'impero Ottomano. Missione Italiana Per L'esplorazione Dei Mari di Levante, Venezia, 187 pp.

Risso, A. (1810): Ichthyologie de Nice ou histoire naturelle des poissons. F. Schoell, Paris, 388 pp.

Silas, E. G. & G. S. D. Selveraj (1972): Descriptions of the adult and embryo of the bramble shark *Echinorhinus brucus* (Bonnaterre) obtained from the continental shelf of India. J. Mar. Biol. Ass. India, 14(1), 395–401.

Tortonese, E. (1956): Fauna d'Italia. Leptocardia, Cyclostomata, Selachii. Calderini, Bologna, 334 pp.

Trois, E. (1876): Notizie sopra l'*Echinorhinus spinosus* per la prima volta osservato nel l'Adriatico. Ibid., 5(3).

original scientific article
received: 2005-01-03

UDC 591.9:597.3 (262-191.2)

OCCURRENCE OF HAMMERHEAD SHARKS (CHONDRICHTHYES: SPHYRNIDAE) IN WATERS OFF SICILY (CENTRAL MEDITERRANEAN): HISTORICAL AND RECENT DATA

Antonio CELONA

Aquastudio Research Institute, I-98121 Messina, via Trapani 6
E-mail: celona.necton@email.it

Alessandro DE MADDALENA

Banca Dati Italiana Squalo Bianco (Italian Great White Shark Data Bank), I-20145 Milano, via L. Ariosto 4

ABSTRACT

*The authors provide a survey on the occurrence of hammerhead sharks off Sicily based on both historical and recent data. The only species identified is the smooth hammerhead *Sphyrna zygaena*. Records of pregnant females and juveniles suggest that the Sicilian Channel could be a potential reproductive area for the smooth hammerhead. Diet included bullet tuna, probably chub mackerel and squid; the first case of a hammerhead feeding on a dolphin has also been recorded. Observed smooth hammerheads often moved in schools. The fishing gears were pelagic longlines, drift nets, hook and line, harpoons and tuna-traps. Hammerheads have greatly declined in the study area in recent years: data from the Palermo area showed a decline of captures of at least 96–98% in the last 30 years.*

Key words: Chondrichthyes, Sphyrnidae, *Sphyrna zygaena*, fishery, Sicily, Italy, Mediterranean Sea

PRESENZA DEI PESCI MARTELLO (CHONDRICHTHYES: SPHYRNIDAE) NELLE ACQUE DELLA SICILIA (MEDITERRANEO CENTRALE): DATI STORICI E RECENTI

SINTESI

*Gli autori svolgono un'indagine sulla presenza dei pesci martello in acque siciliane basandosi su dati storici e recenti. L'unica specie identificata è il pesce martello comune *Sphyrna zygaena*. Le femmine gravide ed i piccoli registrati indicano che il Canale di Sicilia è una potenziale area di riproduzione per il pesce martello comune. La dieta include tombarelli, probabili sgombri e calamari; è stato inoltre registrato il primo caso di un delfino consumato da un pesce martello. I pesci martello comuni osservati nuotavano spesso in banchi. Gli attrezzi utilizzati per la pesca di questi squali sono palangari pelagici, reti derivanti, lenze a mano, arpioni e tonnare. Negli anni recenti questi squali sono drasticamente diminuiti nell'area di studio: i dati relativi alla zona di Palermo indicano una diminuzione delle catture di almeno il 96–98% negli ultimi 30 anni.*

Parole chiave: Condritti, Sphyrnidae, *Sphyrna zygaena*, pesca, Sicilia, Italia, Mare Mediterraneo

INTRODUCTION

Four species of hammerhead sharks were reported from the Mediterranean Sea (Quéro, 1984): the smooth hammerhead *Sphyrna zygaena* (Linnaeus, 1758), the great hammerhead *Sphyrna mokarran* (Rüppell, 1837), the golden hammerhead *Sphyrna tudes* (Valenciennes, 1822), and the scalloped hammerhead *Sphyrna lewini* (Griffith & Smith, 1834), the first of which is the most abundant in the area (Doderlein, 1879–1884; Tuttolomondo, 1899; Tortonese, 1956; Bini, 1967; Vanni, 1992).

The occurrence of *S. zygaena* in the Italian seas has been reported by many authors (Canestrini, 1874; Doderlein, 1879–1884; Tuttolomondo, 1899; Brian, 1906; Tortonese, 1956; Bini, 1967; Vanni, 1992; Mizzan, 1994; Soldo & Jardas, 2002); in the area, the species has been considered infrequent or rare (Canestrini, 1874; Tortonese, 1956; Bini, 1967; Capapé, 1989). Concerning *S. mokarran*, some 300 cm long specimen was caught in a tuna-trap off Camogli, Ligurian Sea, on 21 September 1969 (Boero & Carli, 1977). To date no other great hammerhead has been recorded from the entire Mediterranean area. The presence of *S. tudes* in the Adriatic Sea was described by Canestrini (1874) as very rare. Brusina (1888) reported on a specimen of the golden hammerhead that had been caught in the Kvarner region in the summer of 1888, but admitting that he was not certain about the correct species determination. Kolombatović (1894) determined and reported several young specimens of the small eye hammerhead. Tortonese (1956) examined a 55 cm male preserved in the Museum of Pisa, Italy, caught off Livorno, Italy (Tyrrhenian Sea).

The same author reported on the presence of this species in the Adriatic Sea. Bello (1999) pointed out that the silhouette drawing and the maximum size reported by Šoljan (1975) did not correspond well to the features of this species. Soldo & Jardas (2002) suggested that the presence of *S. tudes* in the Eastern Adriatic must be considered uncertain, whereas Lipej *et al.* (2004) considered the presence of the species in the entire Adriatic Sea as doubtful. Concerning *S. lewini*, Tortonese (1956) reported on examining a specimen captured in the Mediterranean and preserved in the British Museum, London; according to Séret (1999), scalloped hammerheads are occasionally captured in tuna-traps in the Mediterranean. However, this species has never been recorded in Italian waters.

Although sphyrnids have been commonly reported from waters off Sicily, the presence of these large elasmobranchs in this area has never been previously investigated in detail. So, the purpose of this paper is to present a survey of hammerhead sharks recorded off Sicily, based on literature review and recent observations carried out in the area from 2002 to date. The occurrence of hammerhead sharks off Sicily, especially *S. zygaena*, and some aspects of their ecology and reproductive biology are commented herein.

MATERIAL AND METHODS

The study areas are Sicilian waters (Central Mediterranean Sea), Italy, including the Southern Tyrrhenian Sea, Western Ionian Sea and the Channel of Sicily (Fig. 1). This study commenced in 2002 and, although still in progress, the results presented herein are those obtained

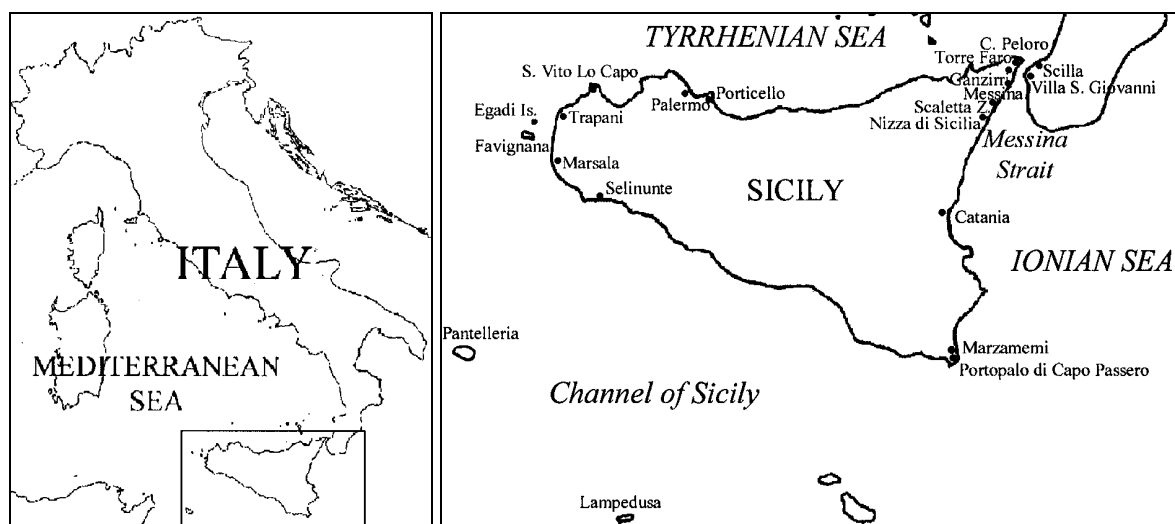


Fig. 1: Area of the Central Mediterranean Sea showing the locations of hammerhead shark captures and sightings presented in this work (Drawing: A. De Maddalena).

Sl. 1: Območje osrednjega dela Sredozemskega morja z lokalitetami, na katerih so bili opažene in ulete v tem članku predstavljene kladvenice (Risba: A. De Maddalena).

up to December 2004. This program is a regional initiative led by the Italian Ichthyological Society (Società Ittiologica Italiana).

The study has been conducted primarily by maintaining contacts with the fishermen and through examination of the fish caught and landed in the area. Through these contacts, many specimens reported by the fishermen were added to those that had been personally examined by one of the authors (A.C.). Additionally, we actively solicited the collaboration and participation of sport fishermen and scuba divers in the study area.

Whenever possible, the following data were collected for each captured specimen: size, weight, sex, stomach contents, fishing gear used for capture, location and date of capture, and catalogue number (cat. no.) in the museum collections. When possible, the size of each specimen was recorded as total length (TOT) measured as a straight line extending from the tip of the snout to the tip of the upper lobe of caudal fin, with the caudal fin in the depressed position; this is also the maximum length (Compagno, 1984). In many cases, however, specimens were not measured but their size was merely estimated by fishermen and divers.

RESULTS

Data of hammerheads from Sicily reported in the previous literature are extremely scarce and all refer to *S. zygaena*. Doderlein (1879–1884) wrote that parturition of *S. zygaena* off Sicily occurs in spring and summer and litter size is between 10–40 embryos, and that in Sicily it is more common in fall and winter. According to Tuttolomondo (1899), in the waters off Catania it is more common in summer. Tortonese (1956) reported captures from Palermo and Messina. According to Bini (1967), it is relatively more abundant in Sicilian waters than in the rest of the Mediterranean. Costa (1991) said this species is rather common in the Messina Strait during June–August. Vanni (1992) reported that a juvenile female caught off Messina on 27 July 1903 is preserved in the Museum of Natural History "La Specola" of the University of Florence (cat. no. 5796). The Museum of Zoology of the University of Palermo keeps four specimens (cat. nos. P-556, P-557, P-558, P-559), whose capture location is unknown but for which it is easy to hypothesise that they may be from Sicilian waters, and a specimen caught in the "Sea of Sicily" before 1890 (cat. no. PL-283).

In the Messina Strait, hammerheads have always been highly valued by professional fishermen. In this area hammerheads were caught with a certain frequency and throughout the year. On average, 10–12 hammerheads were caught each year. From mid-February to end of May, on average 5–7 specimens were taken as bycatch, caught accidentally while fishing for tuna with hook and line. The bait used was the Atlantic mackerel,

Scomber scombrus Linnaeus, 1758, or European sprat, *Sprattus sprattus* (Linnaeus, 1758). From early June to mid-September, numerous hammerheads were sighted from the "feluche", the fishing boats used for capturing swordfish *Xiphias gladius* Linnaeus, 1758, Mediterranean spearfish *Tetrapturus belone* Rafinesque, 1810, and tuna. From the end of September to early December, in the waters Western-North of Capo Peloro, groups of 8 to 12 smooth hammerheads (but maybe only the visible part of larger schools) were sighted quite often even from the seashore. In this season schools of bullet tuna *Auxis rochei rochei* (Risso, 1810) pass from these waters, and hammerheads preyed upon them, as shown by the high number of bullet tuna found in the stomach of some caught hammerheads. Schools of hammerheads were observed in the Messina Strait and closer waters until 1998, but since then their presence that had already decreased in time was no longer observed.

In the summer of 1978, a hammerhead of about 30 kg was caught with a harpoon off Ganzirri by fisherman Antonino Donato, who still has the set of jaws of this specimen preserved (A. Donato, *pers. comm.*). On 2 July 1980, a female weighing about 50 kg was harpooned off Ganzirri; teleost remains, probably chub mackerels *Scomber japonicus* Houttuyn, 1782, were found in its stomach (G. Arena, *pers. comm.*). The set of jaws of this specimen is preserved in one of the author's (A.C.) personal collection. In the summer of 1981, an approx. 100 kg pregnant female hammerhead was caught with a harpoon in the waters of Messina Strait (A. Arena, *pers. comm.*). A 22 kg hammerhead was harpooned and captured off Ganzirri on 4 September 1982. On 16 September 1982, an approx. 70 kg specimen was caught off Torre Faro; the fishing gear used was a drift net called "motulara", used for bullet tuna and Atlantic bonitos, *Sarda sarda* (Bloch, 1793) (F. La Fauci, *pers. comm.*). On 18 July 1983, a male hammerhead of about 130 kg was harpooned from a "feluca" off Scaletta Zanclea; this specimen had one of his claspers cut in half, with a well-healed scar. In the stomach of this specimen, half of a small-sized dolphin, probably a bottlenose dolphin *Tursiops truncatus* (Montagu, 1821), or a striped dolphin *Stenella coeruleoalba* (Meyen, 1833), was found (D. Lisclotto, *pers. comm.*). On 24 October 1983, a 38 kg hammerhead was caught between Punta Pezzo and Villa San Giovanni; the fisherman was fishing for bullet tuna with gear called "filosa", a line carrying twenty hooks with coloured wool as bait. The shark was hooked, and when brought to the surface, the fisherman killed it with harpoon (F. Bagnato, *pers. comm.*). On 10 July 1984, a hammerhead was sighted from a "feluca" off Capo San Ranieri, Messina, and the fishermen approached it with the aim of capturing it, but it escaped (L. Mancuso, *pers. comm.*). A juvenile specimen, weighing only about 15 kg, was caught on 19 October 1984 off Scilla in a drift net (G. Scarfi, *pers. comm.*). On

14 November 1985, off Torre Bianca (Torre Faro), two hammerheads were sighted by a fisherman fishing for bullet tuna with a line from a small boat; the fisherman succeeded in capturing one of the two sharks, weighing about 180 kg, with harpoon, while the second specimen rapidly disappeared (G. Rando, *pers. comm.*). On 23 August, an estimated 250 cm hammerhead was encountered off Nizza di Sicilia by fishermen who were fishing for Atlantic saury *Scomberesox saurus saurus* (Walbaum, 1792); the fishing gear used was a special surrounding net called "ravastina", used only in the Messina Strait by fishermen from Sicily and Calabria. The fishermen attempted to capture the shark, but it escaped (Franco Arena, *pers. comm.*). In the Messina Strait, a large hammerhead was hooked in the night of 26 February 1987 with a line for tuna with European eel *Anguilla anguilla* (Linnaeus, 1758) as bait, but it broke the line (P. Arena, *pers. comm.*). A 96 kg specimen was harpooned and caught in the Strait on 4 August 1987 (F. Donato, *pers. comm.*). In September 1989, a 150 kg male hammerhead was harpooned from a small boat, 600 m off the Strait coast (G. Mancuso, *pers. comm.*). A photograph reproduced in this work (Fig. 2) (C. Pavone, *pers. comm.*), is testimony of the capture of a smooth hammerhead caught in a drift net off the Ionian coast of Sicily in the '90s. A 33 kg male was harpooned and caught off Ganzirri on 14 July 1991 (G. Currò, *pers. comm.*). A 31 kg female was captured with a harpoon off Torre Faro on 26 May 1993 (M. La Fauci, *pers. comm.*). A 41 kg male was harpooned and caught off Ganzirri on 5 August 1999 (A. Arena, *pers. comm.*), and a 130 kg specimen was captured in the same year with hook and line used for capturing tuna and examined by one of the authors (A.C.). At noon on 23 July 2002, an estimated 300 cm hammerhead was seen swimming southwards with its dorsal fin protruding above the surface between Capo Peloro and Scilla; some fishermen who were fishing for swordfish approached the shark in order to capture it, but the animal disappeared (G. Bardetta, *pers. comm.*). On 13 March 2004, a hammerhead estimated to be over 200 cm in length was sighted in the Messina Strait by one of the authors (A.C.).

Another area, where hammerhead sharks were common, was off Palermo. In these waters numerous hammerheads were caught with longlines and drift nets. Porticello di Santa Flavia was the most important landing site in this area. Hammerheads were once abundant in these waters, and 300–400 specimens were caught each year during the summer months in drift nets used for capturing swordfish ("spadare") by one hundred boats belonging to fishermen operating from Porticello di Santa Flavia. Another 50 hammerheads were caught each year in pelagic longlines. But after the late '70s, these sharks become conspicuously less abundant and shortly collapsed. Today the hammerhead is uncommon in these waters, and only 1–2 specimens are caught

each year. The fishermen themselves are perfectly aware that the main reason for this disaster has been the drift net called "spadare". The last hammerhead recorded from this area, an estimated 35 kg gutted specimen, was caught in the summer of 2004 in one of these drift nets (C. Orlando, *pers. comm.*).

In the area around Trapani, the most important landing site is Marsala, where some specimens are caught each year between September and October, by fishing vessels that use pelagic longlines for swordfish with mackerel as bait, fishing about 30 miles north-east of Ustica Island. Hammerheads caught by these vessels are usually landed in Marsala or in San Vito Lo Capo. Until the early '90s, hammerheads were regularly caught by Marsala fishermen in waters 30 miles north of Ustica Island. In this area, each fishing boat caught about 100



Fig. 2: Smooth hammerhead *Sphyrna zygaena* (Linnaeus, 1758) caught in a drift net off the Ionian coast of Sicily, Italy, in the '90s. (Photo reproduced by permission of C. Pavone)

Sl. 2: Navadna kladvenica *Sphyrna zygaena* (Linné, 1758), ujeta v devetdestih letih prejšnjega stoletja v visečo mrežo v Jonskem morju nedaleč od Sicilije. (Fotografija reproducirana z dovoljenjem C. Pavoneja)

hammerheads each year as by-catch of swordfish fishery. Specimens captured in the '80s included even some large individuals, weighing between 150 and 200 kg. Sometimes, hammerheads were also caught in tuna-traps, between spring and summer. A capture that occurred a long time ago in the tuna-trap of Favignana, Egadi Islands, is still remembered by fishermen. From the period 1998–1999, captures of hammerheads from the Trapani area have decreased. An approx. 200 cm hammerhead, probably a male, was caught off Trapani in the late spring 2003, in a net used for capturing bullet tuna (S. Lombardo, *pers. comm.*). Nowadays, hammerheads are uncommon in the Trapani area.

In Selinunte, there are small-medium sized fishing boats that fish for swordfish using longlines, about 10 miles off the western-southern Sicilian coast. Captures of hammerheads were once quite common, but for at least 15 years, these sharks have been rarely encountered in these waters. The last record seems to be that of an estimated 200 cm long specimen, probably a male, caught around the summer of 1998 (V. Cottone, *pers. comm.*).

In the area of Portopalo di Capo Passero and Marzamemi, 6–7 specimens were once captured each year in drift nets and occasionally in tuna-traps, but our search for records from this area seems to indicate that no sightings or captures have occurred for at least ten years.

In the area of Catania, hammerheads were once caught with regularity, both with nets and with longlines for swordfishes and tuna, but since the period 1998–1999, only 1–2 captures occur each year.

Another area frequented by hammerheads is the one around Lampedusa Island in the Sicilian Channel. Until the early '90s, hammerheads were caught regularly by fishermen of Lampedusa, especially from March to September (G. Bolino, *pers. comm.*). These sharks were usually caught along the bank of Levante, 12 miles east of Lampedusa. According to many fishermen, it was quite common to sight from 5 to 10 small sized hammerheads swimming with their dorsal fin protruding above the surface. A single longline usually captured about 6–8 hammerheads. Each fishing boat landed 700–800 kg of hammerheads each year. Almost all specimens were small sized: most had a gutted weight between 15 and 30 kg, but specimens between 7 and 8 kg were also frequently captured. Pregnant females bearing yellow ova of about a centimetre in diameter were also recorded. The fishing gear was usually a pelagic longline used to catch sharks, with the terminal part of the line made of steel. Links between continental Italy and Lampedusa were scarce, and the population of this island used to dry a large amount of fish, included hammerheads and other sharks. Other fishing gears that occasionally captured hammerheads in Lampedusa waters were trammels and hook and line, but usually the specimens caught with the latter system were very small

and fishermen set them free still alive or the sharks even broke the monofilament by themselves. Sometimes, one or two hammerheads would approach fishing boats when these were catching European squids *Loligo vulgaris* (Lamarck 1798) late in the afternoon. Off Lampedusa, squid fishing is carried out as follows. About 80–100 boats cast the anchor in an area of about 400 m², and then attract squids by lights, and these cephalopods congregate in the area in large numbers (G. Bolino, *pers. comm.*). Nowadays hammerheads are rarely sighted along the bank of Levante, and even in this case fishermen are aware that the main reason for this almost total disappearance has been the excessive fishing pressure.

In waters around Lampedusa, encounters with divers have also been recorded. An encounter occurred during a late morning dive, in August 1972, about 10 miles off-shore, about 10 m deep, when the sea was calm. Alessandro Olschki was spearfishing with Paolo Notarbartolo and other divers. Some hammerhead sharks estimated to be about 200 cm long swam at the surface. The sharks simply ignored the divers and left (A. Olschki, *pers. comm.*). In the same area, another encounter took place in the early '80s off Lampedusa coast. Paolo Notarbartolo was filming underwater, when he noticed some hammerhead sharks. Even in this case, the sharks ignored the diver, remaining far from him and then swam away (A. Olschki, *pers. comm.*). Stefano Carletti had some underwater encounters with hammerhead sharks off Lampedusa. One of these encounters occurred in the summer of 1965 off Capo Grecale, at a depth of about 60 m, where a pinnacle rises from the sandy sea bottom. Carletti was spearfishing and was about 15–18 m above the sea floor when he caught sight of an immense school of hammerhead sharks swimming at a depth of about 30 m. The water was limpid, and Carletti had a perfect view of the hammerhead sharks, silhouetted against the surface light. The school consisted of several dozens of individuals measuring up to at least 2 m, swimming in northern direction, completely ignoring both the diver and its speared grouper. During other dives, Stefano Carletti has encountered other hammerheads off Lampedusa, but in these cases the animals occurred singly (S. Carletti, *pers. comm.*).

DISCUSSION

Even if in almost all cases the exact species of hammerhead was not reported, we have to suppose that at least the large majority of the cases reported have to be referred to *S. zygaena*, the only species recorded to date in Sicilian waters.

The specimens, for whom the dimensions were given, ranged from 200 to 300 cm in length and from 15 to 180 kg in weight. The lengths of the specimens fell within the ranges previously described for *S. zygaena* (at least 370 or 400 cm according to Compagno, 1984).

In the study area, hammerhead sharks feed principally on bony fish. Bullet tuna, probably chub mackerels and half of one small-sized dolphin, likely to be bottle-nose or striped dolphin, were found in hammerhead stomachs. This latter case is especially interesting since to the best of our knowledge, even if data of hammerhead diet are numerous in literature (Lineaweaver & Backus, 1970; Ellis, 1983; Compagno, 1984; Stevens, 1984; Castro, 1989; Stevens & Lyle, 1989; Smale, 1991; Last & Stevens, 1994; Cliff, 1995; Barrull *et al.*, 1999); no other cases of *Sphyrna* feeding on dolphins had been reported previously. It is impossible to know whether the young dolphin was alive or dead when it was eaten by the hammerhead. Hammerheads have also been observed feeding on European squid.

A larger sample of adults is required before drawing any conclusions concerning the sex ratio. Gonads were not examined, but at least some specimens had to be mature, on the basis of their size. Pregnant females and numerous juveniles, most probably including newborn specimens, were recorded, indicating that the Sicilian Channel is a potential reproductive area for *S. zygaena*.

These sharks rarely approach divers closely. We are unaware of any aggressive behaviour or incidents involving humans in these waters.

The fact that smooth hammerhead sharks often occur in schools, sometimes of huge size, has been already reported from North Carolina, U.S.A., and South Africa (Bigelow & Schroeder, 1948; Lineaweaver & Backus, 1970; Bass *et al.*, 1975); the reason for these gatherings should be migratory (Bigelow & Schroeder, 1948; Compagno, 1984). The cases recorded in the study area confirm that the behaviour of school forming is common even in the Mediterranean Sea. The regular occurrence of hammerhead schools along the bank of Levante, off Lampedusa, may indicate a behaviour similar to the one described by Klimley *et al.* (1988) for the scalloped hammerheads resident in the area of the sea mount El Bajo Espiritu Santo, Sea of Cortez, where these sharks regularly gather in schools during the day.

Today hammerhead sharks are rarely caught by professional fishermen operating in the study area. Most hammerheads are taken as by-catch, caught accidentally while fishing for other commercial species. Nowadays a specific fishery for hammerhead sharks does not exist in Sicily. There are no regulations or control over the hammerhead shark fishery in Italy. The types of fishing gear used are pelagic longlines, drift nets, hook and line, harpoons and tuna-traps. The baits used are Atlantic mackerels, European sprats, European eels and European flying squid. The pelagic longlines, in which hammerhead sharks are more often caught, are those used for capturing swordfish. The main line is 3.0–5.0 mm thick. At intervals of at least 25 m, 10–25 m long and 1.2–mm thick monofilament lines are attached, each carrying a hook. The total length of these pelagic longlines is usu-

ally 2–40 km, with a total of 200–1500 hooks.

These sharks were retained and sold for human consumption. In Italy, hammerhead shark meat is marketed fresh or frozen for human consumption. It is particularly appreciated in Sicily, where it is considered of high quality and usually destined for domestic consumption and sometimes shipped to other parts of Sicily but rarely to North Italy, where it has low market appeal. In Sicily, hammerhead meat is marketed under the name of "magnusa" (one of the regional names of these sharks), while in other Italian regions it is often marketed under incorrect names and sold as "palombo" (smooth-hound). Hammerheads are often sold at a quite high price in Sicily, up to 7–10 Euro/kg. In the '70s, when hammerheads were caught in large numbers, their price was high, 2000–4000 lire/kg (about 30% of swordfish price at that time).

The absence of previous data on the hammerhead shark fishery in the area does not allow an assessment of the status of their stocks in these waters. According to the local fishermen and to the available data, however, there is no doubt that these sharks have greatly declined in the waters off Sicily. The collected data show that the area off Palermo was the one where hammerhead sharks were captured in higher numbers. A rough estimate, that we have been able to make from the gathered data in respect of this area, indicates a decrease of hammerhead captures of at least 96–98% in the last 30 years.

The abundance of potential food in Sicilian waters was the main reason for the relative abundance of large sharks in the area, as also demonstrated by the data collected on two other species, the great white shark *Carcharodon carcharias* (Linnaeus, 1758) (De Maddalena, 2002) and the bluntnose sixgill shark *Hexanchus griseus* (Bonnaterre, 1788) (*unpubl. data*). Due to its wide distribution, wide prey spectrum, and the fact that it has almost no enemies, the smooth hammerhead may have an important influence on the Mediterranean marine food chain. The dramatic decrease of this species observed in recent decades in the study area have unknown effects on the local fauna.

The reproductive biology of sharks (long sexual maturation times, low fecundity, long gestation periods and relatively small litter size) makes them extremely vulnerable to fishing pressures (Vannuccini, 1999). The collapse of hammerhead presence in Sicilian waters is a clear example of how vulnerable hammerhead sharks can be when they assemble in large schools, and how quickly they can become extinct due to overexploitation.

How badly the pelagic longlines used for tuna and swordfish fishing can endanger the Mediterranean sharks has already been pointed out by numerous authors (Di Natale, 1997; Buencuerpo *et al.*, 1998; Vannuccini, 1999; De Maddalena & Reckel, 2003; Soldo, 2003; De Maddalena & Kideys, 2004; Lipej *et al.*, 2004). Another

threat to sharks is the drift net which, as shown by this study, has greatly damaged hammerhead populations in the past. We found out that this fishing gear is still utilized by some Sicilian fishermen, despite the fact that it was banned in Italy in 1998, following the resolutions of the General Assembly of the ONU (UNGA) and the International Commission for the Conservation of Atlantic Tunas (ICCAT), which expressly prohibited the countries involved to continue using this kind of drift net. The number of fishermen still using the banned "spadare" is unknown.

Immediate effective management of fisheries is needed in order to avoid the hammerheads' total disappearance in the very near future. It is particularly necessary to improve management of fisheries in which sharks constitute a significant by-catch.

ACKNOWLEDGMENTS

Very special thanks to all the people who offered their help in collecting data and general information for this work: Antonino Arena, Franco Arena, Giuseppe Arena, Paolo Arena, F. Bagnato, Giovanni Basciano, the staff of Biotechno in Trapani, Giovanni Bolino, Stefano Carletti, Jeremy Cliff, Giorgia Comparetto, Ernesto Deidda, Antonino Donato, F. La Fauci, D. Lisciotta, Sergio Lombardo, L. Mancuso, Alessandro Olschki, Calogero Orlando, Carmelo Pavone, Antonella Preti, Giuseppe Rando, G. Scarfi and all other fishermen who contributed to the data collection. Special thanks go to Alex Buttigieg, who kindly edited the English text of the manuscript. We also thank the referees for their helpful comments. Special gratitude is expressed by Alessandro De Maddalena to his wife Alessandra and son Antonio.

KLADVENICE (CHONDRICHTHYES: SPHYRNIDAE) V SICILIJSKIH VODAH (OSREDNJE SREDOZEMSKO MORJE): ZGODOVINSKI IN NOVEJŠI PODATKI O POJAVLJANJU TEH MORSKIH PSOVI

Antonio CELONA

Aquastudio Research Institute, I-98121 Messina, via Trapani 6

E-mail: celona.necton@email.it

Alessandro DE MADDALENA

Banca Dati Italiana Squalo Bianco (Italian Great White Shark Data Bank), I-20145 Milano, via L. Ariosto 4

POVZETEK

Avtorji članka predstavljajo pregled pojavljanja kladvenic v sicilijanskih vodah na osnovi zgodovinskih in novejših podatkov o teh morskih psih. Identificirana je bila le vrsta navadna kladvenica *Sphyrna zygaena*. Po podatkih o brejih samicah in mladostnih osebkih bi Sicilski preliv lahko bil razmnoževalni okoliš za navadno kladvenico. Ti morski psi se hranijo s trupci, verjetno pa tudi z lokardami in lignji. Prvič pa je bil zabeležen tudi primer, da se je kladvenica hranila z delfinom. Opazovane navadne kladvenice so se pogosto pojavljale v jatah. Ulovljene so bile s parangali, visečimi mrežami, na trnek, s harpunami in pastmi za tune. V preučevanem območju se je število kladvenic v zadnjih letih močno zmanjšalo; podatki iz palermskih voda celo kažejo, da se je ulov teh morskih psov v zadnjih tridesetih letih skrčil kar za neverjetnih 96–98%.

Ključne besede: Chondrichthyes, Sphyrnidae, *Sphyrna zygaena*, ribištvo, Sicilija, Italija, Sredozemsko morje

REFERENCES

- Barrull, J., I. Mate & M. Bueno (1999):** Observaciones de tiburones (Chondrichthyes Euselachii) en aguas de Cataluña (Mediterráneo NO) con algunos aspectos generales de su ecología. *Scientia gerundensis*, 24, 127–151.
- Bass, A. J., J. D. D'Aubrey & N. Kistnasamy (1975):** Sharks of the east coast of southern Africa. 3. The fami-

lies Carcharhinidae (excluding *Mustelus* and *Carcharhinus*) and Sphyrnidae. *Oceanogr. Res. Inst. (Durban) Investig. Rep.*, 38, 100 pp.

Bello, G. (1999): The Chondrichthyan of the Adriatic sea. *Acta Adriat.*, 40(1), 65–76.

Bigelow, H. B. & W.C. Schroeder (1948): Sharks. *Fishes of the Western North Atlantic (Part one: lancelets, cyclostomes, sharks)*. Memoir Sears Foundation for Marine Research, Yale University, pp. 53–576.

- Bini, G. (1967):** Atlante dei Pesci delle coste italiane. Vol.1. Leptocardi, Ciclostomi, Selaci. Mondo Sommerso, Roma, 206 pp.
- Boero, F. & A. Carli (1977):** Prima segnalazione mediterranea di *Sphyrna mokarran* (Rüppell) (Selachii, Sphyrnidae). Boll. Mus. Ist. Biol. Univ. Genova, 45, 91–93.
- Brian, A. (1906):** Copepodi parassiti dei Pesci d'Italia. Istituto Sordomuti, Genova, 192 pp.
- Brusina, S. (1888):** Morski psi Sredozemnoga i Crljenog mora. Glasnik hrvatskoga naravoslovnoga društva, Zagreb, III, 167-230.
- Buencuerpo, V., S. Rios & J. Moron (1998):** Pelagic sharks associated with the swordfish, *Xiphias gladius*, fishery in the eastern North Atlantic Ocean and the Strait of Gibraltar. Fish. Bull., 96(4), 667–685.
- Canestrini, G. (1874):** Fauna d'Italia. Parte terza. Pesci. Vallardi, Milano, 208 pp.
- Capapé, C. (1989):** Les Sélaciens des côtes méditerranéennes: aspects généraux de leur écologie et exemples de peuplements. Océanis, 15(3), 309-331.
- Castro, J. I. (1989):** Biology of the Golden Hammerhead, *Sphyrna tudes*, off Trinidad. Environ. Biol. Fishes, 24(1), 3–11.
- Cliff, G. (1995):** Sharks caught in the protective gill nets off Kwazulu-Natal, South Africa. 8. The great hammerhead shark *Sphyrna mokarran* (Rüppell). S. Afr. J. Mar. Sci., 15, 105–114.
- Compagno, L. J. V. (1984):** FAO species catalogue. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. FAO Fish. Synop., 125(4), 1–656.
- Costa, F. (1991):** Atlante dei pesci dei mari italiani. Mursia, Milano, 429 pp.
- De Maddalena, A. (2002):** Lo squalo bianco nei mari d'Italia. Ireco, Formello, 144 pp.
- De Maddalena, A. & A. Kideys (2004):** Summary of discussions on Topic 1.1: The role of top predators (incl. gelatinous organisms) and large nekton (incl. whales & dolphins, seals, sharks, turtles) in biodiversity. In: Magni, P., A. Malej, S. Moncheva, E. Vanden Berghe, W. Appeltans, D. Cuvelier, P. H. van Avesaath, H. Hummel, C. H. R. Heop & J. Mees (eds): Electronic conference on "The Southern and Eastern Mediterranean Sea and the Black Sea: New challenges for marine biodiversity research monitoring". 6–24 September, 2004, Flanders Marine Institute (VLIZ), Oostende, p. 55–63.
- De Maddalena, A. & F. Reckel (2003):** Haie in Mittelmeer. Biol. Unserer Zeit, 33(4), 257–263.
- Di Natale, A. (1997):** By-catch of shark species in surface gear used by the Italian fleet for large pelagic species. SCRS/97/118 Coll. Vol. Sci. Pap., p. 138–140.
- Doderlein, P. (1879-1884):** Manuale ittiologico del Mediterraneo. Tipografia del Giornale di Sicilia, Palermo.
- Ellis, R. (1983):** The book of sharks. Revised edition. Robert Hale, London, 256 pp.
- Kolombatović, J. (1894):** O navodima vrsti meči i kralježnjaka iz Jadranskog mora. Izvješće Vel. Realke, Split, 1–58.
- Klimley, A. P., S. B. Butler, D. R. Nelson & A. T. Stull (1988):** Dial movements of scalloped hammerhead sharks (*Sphyrna lewini* Griffith and Smith) to and from a seamount in the Gulf of California. J. Fish Biol., 33, 751–761.
- Last, P. R. & J. D. Stevens (1994):** Sharks and rays of Australia. CSIRO, Australia, 514 pp.
- Lineaweaver III, T. H. & R. H. Backus (1969):** The Natural History of Sharks. Lippincott, Philadelphia, 256 pp.
- Lipej, L., A. De Maddalena & A. Soldo (2004):** Sharks of the Adriatic Sea. Knjižnica Annales Majora, Koper, 254 pp.
- Mizzan, L. (1994):** I Leptocardi, Ciclostomi e Selaci delle collezioni del Museo Civico di Storia Naturale di Venezia. 1. Leptocardia, Agnatha, Gnathostomata – Chondrichthyes (esclusi Rajiformes). Boll. Mus. Civ. Stor. Nat. Venezia, 45, 123–137.
- Quéro, J.-C. (1984):** Sphyrnidae. In: Whitehead, P. J. P., M.-L. Bauchot, J.-C. Hureau, J. Nielsen & E. Tortonese (eds.): Fishes of the north-eastern Atlantic and the Mediterranean. Vol. 1. UNESCO, Paris, p. 122–125.
- Séret, B. (1999):** Les requins des côtes françaises. Editions Ouest-France, Rennes, 32 pp.
- Smale, M. J. (1991):** Occurrence and feeding of three shark species, *Carcharhinus brachyurus*, *C. obscurus*, and *Sphyrna zygaena*, on the eastern Cape coast of South Africa. S. Afr. J. Mar. Sci., 11, 31–42.
- Soldo, A. (2003):** Status of sharks in the Mediterranean. Annales Ser. Hist. Nat., 13(2), 191–200.
- Soldo, A. & I. Jardaš (2002):** Large sharks in the Eastern Adriatic. Proc. 4th Elasm. Assoc. Meet., Livorno, Italy, 2000. ICRAM, ARPAT & SFI, p. 141–155.
- Šoljan, T. (1975):** I pesci dell'Adriatico. Arnoldo Mondadori Editore, Verona, 522 pp.
- Stevens, J. D. (1984):** Biological observations on sharks caught by sport fishermen off New South Wales. Aust. J. Mar. Freshw. Res., 35, 573–590.
- Stevens, J. D. & J. M. Lyle (1989):** Biology of three hammerhead sharks (*Eusphyrna blochii*, *Sphyrna mokarran*, and *S. lewini*), from northern Australia. Aust. J. Mar. Freshw. Res., 40, 129–146.
- Tortonese, E. (1956):** I Pesci e i Cetacei del Mar Ligure. Mario Bozzi, Genova.
- Tuttolomondo, A. (1899):** Fauna ittiologica del compartimento marittimo di Catania. Girgenti.
- Vanni, S. (1992):** Cataloghi del Museo di Storia Naturale dell'Università di Firenze, Sezione di Zoologia "La Specola". XI. Chondrichthyes. Atti Soc. Tosc. Sci. Nat. Mem. B, 99, 85–114.
- Vannuccini, S. (1999):** Shark utilization, marketing and trade. FAO Fish. Tech. Paper, 389, p. 1–470.

short scientific article
received: 2005-01-06

UDC 591.9:597.3 (262.5)

PONTIC OCCURRENCE OF THE BLUNTNOSE SIXGILL SHARK, *HEXANCHUS GRISEUS* (BONNATERRE, 1788) (CHONDRICHTHYES: HEXANCHIDAE)

Hakan KABASAKAL

Ichthyological Research Society, Atatürk mahallesi, Menteşoğlu caddesi, İdil apt., No: 30/4, Ümraniye, TR-34764 İstanbul, Turkey
E-mail: hakankabasakal@hotmail.com

ABSTRACT

On 19 November 2004, one male specimen of Hexanchus griseus of 300 cm TOT and weighing 250 kg was captured by a commercial gill-netter nearly 3 miles off the coast of Amasra (SW Black Sea, western Anatolian coast). This single capture extends the Mediterranean distribution of H. griseus to the Black Sea and confirms its pontic occurrence.

Key words: *Hexanchus griseus*, sixgill shark, hexanchidae, Black Sea, distribution

PRESENZA PONTICA DI SQUALO CAPOPIATTO *HEXANCHUS GRISEUS* (BONNATERRE, 1788) (CHONDRICHTHYES: HEXANCHIDAE)

SINTESI

Il 19 novembre 2004 un esemplare maschio di Hexanchus griseus, di 300 cm di TOT e 250 kg di peso, è stato catturato con una rete commerciale per piccoli pesci cartilaginei, tre miglia al largo della costa di Amasra (Mar Nero sud-occidentale, costa anatolica occidentale). Questa singola cattura estende al Mar Nero la distribuzione mediterranea di H. griseus e conferma la sua presenza pontica.

Parole chiave: *Hexanchus griseus*, squalo capopiatto, Hexanchidae, Mar Nero, distribuzione

INTRODUCTION

Hexanchus griseus (Bonnaterre, 1788) is a wide ranging species in temperate and tropical seas, including Mediterranean and adjacent waters, living at depths from the surface to at least 1875 m (Boeseman, 1984; Compagno, 1984; Bauchot, 1987; Capape *et al.*, 2003). Occurrence of the bluntnose sixgill shark in the Black Sea has always been a point of discussion. In a very old and questionable record by Geldiay (1969, in Bilecenoğlu *et al.*, 2002), the author reported on the presence of *H. griseus* from the Black Sea, without giving any information on the fishing locality of the examined specimen, or the name of the institution, where the specimen is preserved for further inspection. Due to the lack of adequate information, Bilecenoğlu *et al.* (2002) considered this pontic recording of *H. griseus* by Geldiay (1969) as 'questionable' and requiring confirmation. In the monumental works by Slattenenko (1956) and Akşiray (1987), the authors did not report on the presence of bluntnose sixgill shark from the Black Sea. In a recent study by Kabasakal (2004), the author reported on a capture of a single specimen of *H. griseus* in the prebosphoric Black Sea waters, where their physical conditions are practically under the influence of the Marmaric current. Because of this reason, Kabasakal (2004) emphasized the necessity of further research in order to reveal whether the pontic distribution of *H. griseus* extends throughout the entire Black Sea.

In this short communication paper, new data on the capture of a bluntnose sixgill shark off the Anatolian coast of the southwestern Black Sea is presented and its pontic distribution discussed.

MATERIAL AND METHODS

This study is part of an extensive ongoing research, which was launched in 2002, in order to investigate the distribution of *Hexanchus griseus* in Turkish waters. Data have been collected from the following sources: 1) fishing logs of commercial vessels; 2) records of local fish markets; 3) field surveys; and 4) notes appearing in daily newspapers, fishing magazines, etc. The author was informed about the capture of a specimen of *H. griseus* off the coast of Amasra (SW Black Sea) on 19 November 2004, after reading an article in a local newspaper. Although the sixgill shark was immediately eviscerated and sold at a local fish market, the fisherman provided a photograph of the captured specimen taken from its left side. Identification of this specimen was made on the basis of this photograph, now kept in the author's personal archive. The species identification follows Compagno (1984). Total length (TOT) and weight data were provided by the fisherman.



Fig. 1: Male specimen of *Hexanchus griseus* of 300 cm TOT and weighing 250 kg, captured off the coast of Amasra (SW Black Sea).

Sl. 1: Samec šesteroškrgarja *Hexanchus griseus*, 300 cm celotne iztegnjene dolžine in težak 250 kg, ujet v mrežo slabe 3 milje od obale Amasre (JZ Črno morje).

RESULTS AND DISCUSSION

On 19 November 2004, one male specimen of *Hexanchus griseus* of 300 cm TOT and weighing 250 kg (Fig. 1) was captured by a commercial gill-netter nearly 3 miles off the coast of Amasra (SW Black Sea, western Anatolian coast; Fig. 2). On the photograph taken of the specimen (Fig. 1), 6 gill slits are clearly visible on the left side of the head, which enabled the author to identify the captured specimen as *H. griseus*. Unfortunately, as the sixgill shark was immediately eviscerated and sold at a local fish market, no biometrical measurements of this pontic specimen could be made.



Fig. 2: Map showing the capture localities of prebosphoric (●) and Amasra specimens (▲) of *H. griseus*.

Sl. 2: Zemljevid z lokalitetami ujetih prebosporskih primerkov vrste *H. griseus* (●) in primerka, ujetega v bližini Amasre (▲).

Although, *H. griseus* can penetrate to shallow areas and even rise to surface waters, particularly at night (Boeseman, 1984; Dunbrack & Zielinski, 2003), it normally inhabits deep water over the continental shelf and upper slope to at least 1875 m (Compagno, 1984). Regarding the chemical properties of sea water in bathyal zone of the Black Sea, the water column below 200 meter is contaminated with hydrogen sulphur (Prodanov *et al.*, 1997), a toxic substance which kills any marine organism depending aerobic conditions. Therefore, it is possible to suppose that in the Black Sea, bluntnose sixgill shark can not survive at depths below 200 metres

due to the anaerobic conditions prevailing in the bathyal pontic waters. This circumstance seems to be a critical factor, which can restrict the depth distribution of *H. griseus* in the Black Sea to a significantly shallower zone than other seas of the world. For the moment, no adequate data is available to validate the hypotheses that the bluntnose sixgill shark inhabits a narrow depth range from the surface to 200 metres in the Black Sea. However, this single capture extends the Mediterranean distribution of *H. griseus* to the Black Sea and confirms its pontic occurrence.

ŠESTEROŠKRGAR *HEXANCHUS GRISEUS* (BONNATERRE, 1788) (CHONDRICHTHYES: HEXANCHIDAE), UJET V JUGOZAHODNIH VODAH ČRNEGA MORJA

Hakan KABASAKAL

Ichthyological Research Society, Atatürk mahallesi, Menteşoğlu caddesi, İdil apt., No: 30/4, Ümraniye, TR-34764 İstanbul, Turkey
E-mail: hakankabasakal@hotmail.com

POVZETEK

Dne 19. novembra 2004 se je skoraj 3 milje od obale Amasre (JZ Črno morje, zahodna obala Anatolije) v stoječo mrežo nekega poklicnega ribiča ujel samec šesteroškrjarja *Hexanchus griseus* (celotna iztegnjena dolžina 300 cm, teža 250 kg). Ta edini primerek potrjuje pojavljanje te vrste v Črnem morju in hkrati podaljšuje njegovo sredozemsko razširjenost do črnomorskih voda.

Ključne besede: *Hexanchus griseus*, šesteroškrjar, Hexanchidae, Črno morje, razširjenost

REFERENCES

- Akşiray, F. (1987):** Türkiye Deniz Balıkları ve Tayin Anahtarı. 2nd Edition. Publications of Istanbul University, no. 3490, İstanbul, 811 pp.
- Bauchot, M. -L. (1987):** Requins. In: Fischer, W., M. Schneider & M. -L. Bauchot (eds.): Fiches FAO d'identification des espèces pour les besoins de la pêche. (Révision 1). Méditerranée et mer Noire. Zone de pêche 37. Vol. II. Vertébrés. FAO, Roma, p. 767–843.
- Bilecenoglu, M., E. Taskavak, S. Mater & M. Kaya (2002):** Checklist of the marine fishes of Turkey. Zootaxa 113. Magnolia Press, Auckland, 194 pp.
- Boeseman, M. (1984):** Hexanchidae. In: Whitehead, P. J. P., M. -L. Bauchot, J. -C. Hureau, J. Nielsen & E. Tortonese (eds.): Fishes of the North-eastern Atlantic and the Mediterranean. Vol. I. UNESCO, Paris, p. 72–75.
- Capapé, C., O. Guélorget, J. Barrull, I. Mate, F. Hemida, R. Seridji, J. Bensaci & M. N. Bradaï (2003):** Records of the Bluntnose six-gill shark, *Hexanchus griseus* (Bonnaterre, 1788) (Chondrichthyes: Hexanchidae) in the Mediterranean Sea: A historical survey. Annales Ser. Hist. Nat., 13(2), 157–166.
- Compagno, L. J. V. (1984):** FAO species catalogue. Vol. 4. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Part 1. Hexanchiformes to Lamniformes. FAO Fish. Synop., 125(4), 1–249.
- Dunbrack, R. & R. Zielinski (2003):** Seasonal and diurnal activity of sixgill sharks (*Hexanchus griseus*) on a shallow water reef in the Strait of Georgia, British Columbia. Can. J. Zool., 81(6), 1107–1111.
- Geldiay, R. (1969):** Important fishes found in the Bay of İzmir and their possible invasions. Monographs. Ege University, Faculty of Sciences, İzmir, 135 pp.

Kabasakal, H. (2004): Preliminary observations on the reproductive biology and diet of the Bluntnose sixgill shark, *Hexanchus griseus* (Bonnaterre, 1788) (Chondrichthyes: Hexanchidae), in Turkish Seas. Acta Adriat., 45(2), 197–206. (in press)

Prodanov, K., K. Mikhailov, G. Daskalov, C. Maxim, A. Chaschin, A. Arkhipov, V. Shlyakhov & E. Özdamar

(1997): Environmental management of fish resources in the Black Sea and their exploitation. Studies and Reviews. General Fisheries Council for the Mediterranean. No. 68. Rome, FAO, 178 pp.

Slastenenko, E. (1956): Karadeniz Havzası Balıkları (The Fishes of the Black Sea Basin). Et ve Balık Kurumu Yayınlarından, İstanbul, 711 pp. (in Turkish)

original scientific article
received: 2004-09-03

UDC 582.272:581.4/.5(262.3-18)

MORPHOLOGICAL AND REPRODUCTIVE PHENOLOGY OF *CYSTOSEIRA COMPRESSA* (ESPER) GERLOFF & NIZAMUDDIN (FUCALES, FUCOPHYCEAE) IN THE GULF OF TRIESTE (NORTH ADRIATIC SEA)

Annalisa FALACE, Elisa ZANELLI & Guido BRESSAN

Università degli Studi di Trieste, Dipartimento di Biologia, I-34127 Trieste, Via L. Giorgieri 10, Italy
E-mail: falace@univ.trieste.it

ABSTRACT

In a wider context regarding the characterization of Cystoseira populations, studies concerning growth and reproduction resulted to be particularly important for a wider understanding of species' abundance and distribution, and therefore of the community structure, also with the aim of environmental restoration and mitigation in partially degraded areas. Only partial data are available on the morphological and reproductive phenology of Cystoseira compressa. In order to define for the northern Adriatic Sea the variability of diacritic characteristics of this species, and to evaluate the seasonal periodicity of growth and reproduction, a study was carried out at Izola (Slovenia). 6 thalli of C. compressa were taken randomly, every month, for one year and morphometric parameters were measured for every sample. The morphological plasticity of the thallus and the phenological cycle, characterized by the succession of two dominant forms, were described.

Key words: *Cystoseira compressa*, phenology, morphology, Gulf of Trieste, northern Adriatic Sea

FENOLOGIA MORFOLOGICA E RIPRODUTTIVA DI *CYSTOSEIRA COMPRESSA* (ESPER) GERLOFF & NIZAMUDDIN (FUCALES, FUCOPHYCEAE) NEL GOLFO DI TRIESTE (NORD ADRIATICO)

SINTESI

Studi sulla crescita e riproduzione di specie algali risultano particolarmente importanti ai fini di interventi di restauro e mitigazione di aree degradate. Allo scopo di definire la fenologia morfologica e riproduttiva e la variabilità stagionale dei caratteri diacritici di Cystoseira compressa è stato condotto uno studio nel Nord Adriatico ad Izola (Slovenia). 6 talli di C. compressa sono stati raccolti random mensilmente per un anno e sono stati analizzati i parametri morfometrici. Vengono descritti la plasticità morfologica del tallo, caratterizzato dalla successione di due forme dominanti, ed il ciclo fenologico.

Parole chiave: *Cystoseira compressa*, fenologia, morfologia, Golfo di Trieste, Nord Adriatico

INTRODUCTION

The genus *Cystoseira* C. Agardh (Fucales, Fucophyceae) is characterized by a notable taxonomic complexity and a wide infra- and intra-specific polymorphism, depending on geographical distribution and ecological conditions (Gómez *et al.*, 1982; Barcelo & Seoane Camba, 1984; Motta, 1989; Oliveras & Gómez-Garreta, 1989; Cormaci *et al.*, 1992; Serio, 1995; Otero-Schmitt & Pérez-Cirera, 1996; Pizzuto 1998; Alongi *et al.*, 1999; Marzocchi *et al.*, 2003). Key reports on *Cystoseira* genus are the study of Savaugau (1912), focusing mainly on the species of the European Atlantic as Western Mediterranean coasts, the monographs by Valiante (1883) on the Gulf of Naples species and by Ercegović (1952) on the Adriatic species.

According to Roberts (1978), this genus is in progress of active speciation and the biogeography of *Cystoseira* species has been investigated by Giaccone (1991); for the Mediterranean Sea, Ribera *et al.* (1992) reported 29 species, 15 varieties and 13 forms, however, for an accurate evaluation of species, variety and form number, one must also take into consideration the recent revisions by Gómez-Garreta (2000) and Furnari *et al.* (2003). In order to solve problems linked to the taxonomy and evolutionary biology, several studies have been carried out on distribution, growth, morphology and chemistry of different species (Giaccone & Bruni, 1971, 1973; Giaccone, 1973; Khailov, 1978, 1979; Firsov & Khailov, 1979; Khailov & Firsov, 1979; Amico *et al.*, 1985; Giaccone & Motta, 1987; Piattelli, 1990; Hoffmann *et al.*, 1992; Ribera *et al.* 1992, 1995; Amico, 1995; Montesanto & Panayotidis, 2001). In the Mediterranean, *Cystoseira* stands often represent a climax stage in photophilous communities. The development of these canopy algae, referred to as keystone species (*sensu* Paine, 1969) or ecological engineering species (*sensu* Jones *et al.*, 1994), ranging from shallower to sub-littoral rocky shore in exposed or sheltered situations, leads to an increase of space heterogeneity forming complex communities (Ballesteros, 1988; Rull & Gómez-Garreta, 1990; Benedetti-Cecchi *et al.*, 2001; Falace & Bressan, 2004; Falace & Bressan, *in press*). The canopy can modulate the structure of the biotic community, modifying the rates of recruitment and mortality of the epibionts and may affect the density and efficiency of predators, providing shade and shelter for diversified assemblages of animals and algae (Boudourisque, 1971; Tigànus, 1972; Celan & Bavaru, 1978; Hicks, 1980; Dean & Connell, 1987; Beleggratis & Bitis, 1989; Aarnio & Mattila, 2000; Hernández-Carmona *et al.*, 2000). Furthermore, it plays a crucial role on understorey assemblage's growth by significantly affecting the physical factors, such as light (Reed & Foster, 1984; Kennelly, 1989; Figueiredo *et al.*, 2000; Melville & Connell, 2001), desiccation (Menge, 1978; McCook & Chapman, 1991), currents and the rates of transport and deposition

of suspended particulates (Hawkins, 1983; Jenkins *et al.* 1999; Airoldi, 2003; Piani *et al.*, 2004).

Several *Cystoseira* species have been enclosed, as sensitive species, among the marine coastal indicators of environmental quality (Montesanto & Panayotidis, 2001). In the Mediterranean, in fact, the increase in eutrophication and pollution, as a result of natural and anthropogenic disturbances, has been accompanied by a decline of *Cystoseira* belts (UNEP, 1996; Cormaci & Furnari, 1999; Munda 1993a, 1993b, 2000; Falace, 2000; Falace & Bressan, 2003). Over the last three decades, environmental alterations in the Adriatic Sea have changed the floristic diversity and leading algal associations, and a marked qualitative/quantitative decline of macrophytes occurred (Munda 1991, 1993a, 1993b, 2000; Sfriso *et al.*, 1993; Cormaci & Furnari, 1999; Falace, 2000; Falace & Bressan, 2003; Falace *et al.*, *in press*). The principal variations observed concern the increase of opportunistic, with rapidly growing turfed species, and the reduction/disappearance of leathery Fucales (Falace, 2000; Falace & Bressan, 2003). At present, *Cystoseira barbata* (Stackhouse) C. Agardh and *Cystoseira compressa* (Esper) Gerloff & Nizamuddin are the only species belonging to this genus still present in the surrounding of Trieste, in relation to their wider tolerance to environmental stresses (Falace, 2000).

In a wider context of research on the architectural complexity of *Cystoseira* (Falace & Bressan, 2004; Falace & Bressan, *in press*; Piani *et al.*, 2004), a study was conducted in the North Adriatic Sea aimed at analysing the phenology of *C. compressa*, in order to evaluate for this biogeographical area the seasonal periodicity of growth and reproduction.

MATERIALS AND METHODS

The study was carried out in a protected sea area near Izola (Slovenia) (45°32'41.3" N, 13°40'39.2" E) (Fig. 1). The area is located in the Gulf of Trieste (northern Adriatic Sea), a semi-enclosed shallow system (max. depth 25 m) characterized by strong river run-off and wide seasonal and inter-annual temperatures and salinity variability. Variations within the current system are highly dependent on the *bora* wind, which blows in an offshore direction (Mosetti, 1972; Zore Armanda & Gačič, 1987). The tidal range is 97 cm on average. Surface sediments have been subdivided by Ogorelec *et al.* (1991) into seven zones on the basis of grain-size and mineral composition. The sedimentation rate estimated in the central part of the Gulf is 1.08 mm yr⁻¹, whereas at 5 km from the Isonzo River mouth it is 1.45 mm yr⁻¹ (Bertuzzi *et al.*, 1996).

Samples were collected in the upper sublittoral zone on semi exposed rocky low-shores characterised by a dense population of *C. compressa*, which extends down to 2 metres depth (Fig. 1). In the inner part of the

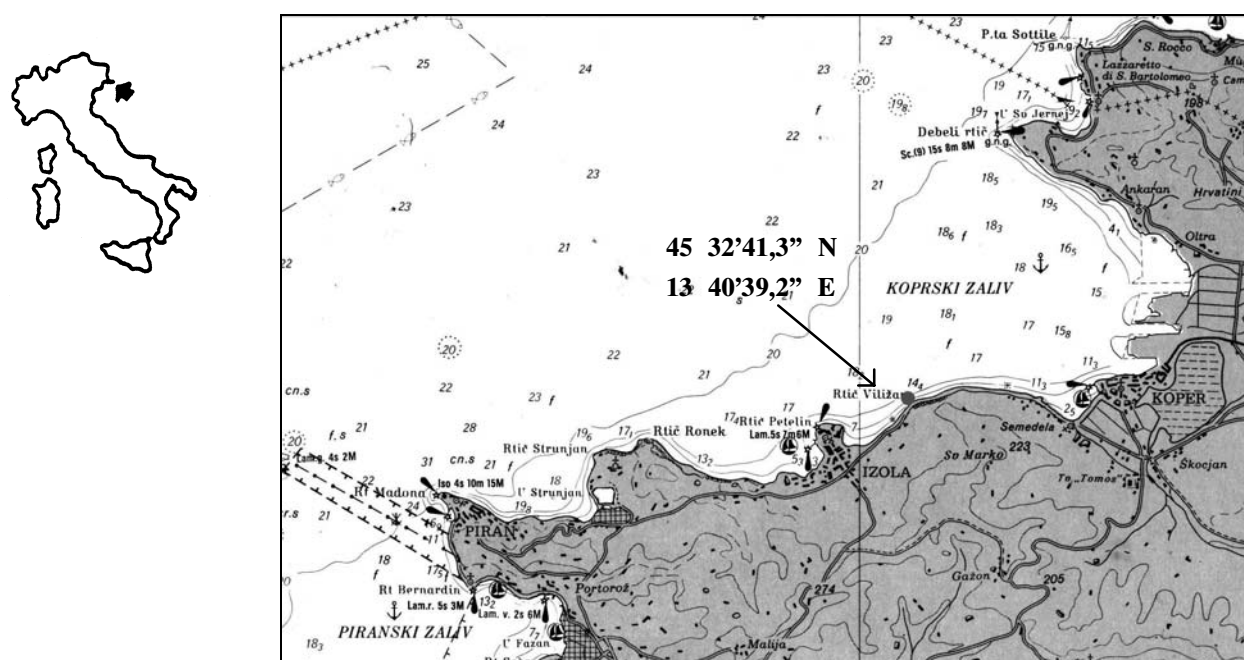


Fig. 1: Sampling site (Izola, Slovenia).
Sl. 1: Vzorčišče (Izola, Slovenija).

small Bay of Izola, surface sediments mainly consist of clayey silt, although in shallow shores the prevailing sediment is sand. Six thalli of *C. compressa* were taken at random every month for one year (April 2002–March 2003), apart from June, August and December, due to international bureaucratic impediments. They were fixed in a 4% formalin seawater solution and send to the laboratory. The morphology was described and the following measures were carried out: the overall height from the basal disc to the apex of the frond; the length of 10, chosen at random, I branches; the diameter of 10 I branches, at 1 cm from the ramification from the cauloid and at half the length of the branch; the length and diameter in the middle of the axis of 5, selected at random, II branches. The reproductive phenology was examined, describing the presence of fertile conceptacles.

RESULTS

Morphology of the thallus

C. compressa is a caespitose plant attached to the substratum by a small disc. From November to January, the analysed samples show a "rosette-shaped" form, characterized by flattened I branches, smooth borders and rounded apex. The II branches are short, distichous and alternate. At the base of I and II branches a middle-rib is well distinguishable. The cryptostomata (depressions with hair tufts) are arranged, on both I and II branches, in two rows from the base to the apex. In January, the ramifications appear denser near the apex and sparse in the basal portion of the thallus; I and II

branches are still flattened.

In February-March, the examined thalli present a transitory shape, with the coexistence on the same plant of two different typologies of I branches: a) short and flattened like in the winter form; b) lengthened and thin towards the upper of the axis with cryptostomata arranged in different layers. In transversal section, these branches appear to be cerebral-shaped or more or less triangular-elliptical in the upper portion, whereas at the base they are still flattened. Near the apex of the fronds, the II branches are thin and thick, ramified, and disposed on more layers, whereas at the base they are alternate, distichous with the cryptostomata disposed on two strings. The aerocysts (air-bladders) first appear, starting from April, on the more apical II branches. The aerocysts can be isolated or disposed in chain.

In spring/beginning of summer, the thallus bearing changes and it becomes erect and densely ramified, especially in the apical region. The I branches are still broader at the base and cylindrical at the apex, while II branches become longer, thinner and ramified. In July, some thalli present roundish I branches with a bare section in the basal portion, above which II branches are less densely ramified. The aerocysts appear less numerous and partly deformed.

At the end of summer/beginning of autumn, the thallus regains the winter "rosette-shaped" bearing; the change occurs with the fall of older branches, which are substituted by new ones with a flattened portion of relatively growing importance, and alternated distichous II branches. The aerocysts are absent.

	Thalli		I branch		I branch (diam. 1 cm)		I branch (diam. half length)		II branch		II branch (diam. half length)		Con- cept.
Month	length	SEM	length	SEM	length	SEM	length	SEM	length	SEM	length	SEM	
Apr	255.6	9.8	170.4	11.1	2.6	0.1	1.5	0.1	49.7	3.2	1.4	0.1	
May	448.3	27.7	324.3	24.5	2.5	0.1	1.5	0.1	100.4	5.9	0.9	0.0	*
Jul	251.2	79.3	132.3	27.8	1.9	0.1	1.5	0.1	62.7	5.8	1.0	0.1	*
Sep	62.5	9.2	35.6	2.3	1.9	0.1	2.0	0.1	17.7	1.3	1.9	0.1	
Oct	61.7	6.8	24.9	3.3	2.5	0.2	2.7	0.2	12.9	1.0	2.4	0.1	
Nov	54.0	3.8	33.5	4.1	2.7	0.2	2.7	0.1	13.1	1.0	2.9	0.1	
Jan	60.8	6.3	35.4	4.6	2.6	0.2	2.4	0.1	13.9	0.9	3.0	0.1	
Feb	120.3	9.9	75.9	6.6	2.4	0.2	1.8	0.1	20.4	1.2	2.0	0.2	
Mar	128.3	13.9	79.3	8.6	2.7	0.1	2.1	0.1	33.6	1.6	2.3	0.1	

Tab. 1: Phenological data (SEM: mean standard error). Measurements are in mm.

Tab. 1: Fenološki podatki (SEM: srednja standardna napaka). Mere so izražene v mm.

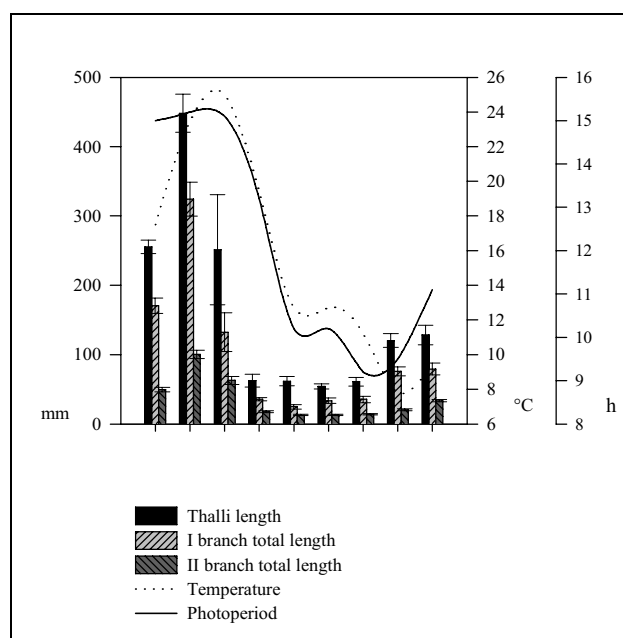


Fig. 2: Diagram of thalli, I and II branches average lengths related to the photoperiod and temperature trend.

Sl. 2: Diagram steljke in povprečne dolžine poganjkov I in II glede na fotoperiodične in temperaturne trende.

Height of the thallus

The monthly average values vary from a minimum of 54 mm in November to a maximum of 448.3 mm in May (Tab. 1). The maximum vegetative development is observed in spring/summer, in accordance with the higher temperature and photoperiod length in the study area (Fig. 2). Starting from September, with the gradual changes in temperature and photoperiod, the reduction in the size of the frond is attained.

Primary branches

I branches (Tab. 1, Fig. 2) are more developed during April-July (average length 209.0 mm) with a maximum in May (324.3 mm). From September, the thalli lose their fronds, and in October I branches reach their minimum (24.9 mm). Following the seasonal cycle, the frond, besides varying in sizes, also changes from a morphological point of view. In fact, from April to July, I branches appear to be flattened at the basal part, whereas towards the apex they are thin and cylindrical. In September, with the fall of older branches and the contemporary growth of new ones, the frond takes the "rosette-shaped" form that remains till January; in February, the change towards a more developed and erect form of the thallus is observed, characterized by cylindrical branches with thinner apices and bases, and thicker II branches. During these morphological variations, the diameter of the I branches at 1 cm from the ramification from the cauloid varies between a minimum of 1.9 mm in July and September to a maximum of 2.7 mm in November and March (Tab. 1, Fig. 3). A similar pattern may be observed for the diameter at half the length of the I branch: the minimum (1.5 mm) is reached between April and July, when the branches are cylindrical, while the maximum (2.7 mm) is observed between October and November, when the thallus takes on the winter form.

Secondary branches

The length : diameter ratio of II branches follows the same trend as recorded for I branches (Fig. 3). In May, the average length reaches the maximum (100.4 mm) and the diameter the minimum (0.9 mm). In April-July, during the greatest vegetative development, the length of II branches (Tab. 1, Fig. 2) reaches the highest values (49.7-100.4 mm), while the minimum (17.7-13.1 mm) is recorded starting from September.

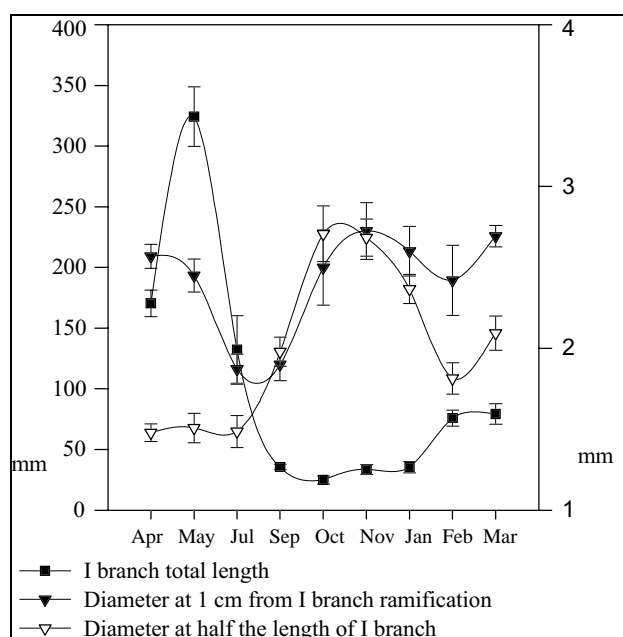


Fig. 3: Diagram of the I branches total length and diameter, measured at 1cm from the ramification and at half the length.

Sl. 3: Diagram poganjkov I, skupna dolžina in premer, izmerjen 1 cm od razrasti in na polovici njihove dolžine.

Reproductive phenology

Matured conceptacles can be observed during the May-July period (Tab. 1). The receptacles at the apices of terminal branchlets are pedunculate, bi-trifurcated and present internal aerocysts, while the receptacles in the lower part of the branches are lacking in aerocysts.

DISCUSSION AND CONCLUSIONS

Unlike other species of the same genus, the phenology of *C. compressa* has been poorly investigated and

only partial data, concerning the reproductive-vegetative cycle, are available. The *C. compressa* thallus presents a morphological plasticity, which is very changeable in size and appearance in relation to the principal environmental parameters, and in particular according to the wave-exposure: in exposed shores, the predominant life-form is the rosette-shaped one (Hamel, 1939; Gómez-Garreta, 2000). The name *Cystoseira abrotanifolia* (Linnaeus) C. Agardh has been misapplied by several authors as a synonym of *C. compressa* (Gómez-Garreta, 2000). John et al. (2004) cite *Cystoseira abrotanifolia* (Stackh.) C. Agardh and *Cystoseira fimbriata* (Desf.) Bory, as synonyms of this species. Ercegović (1952) included thalli from the exposed sites in a subspecies (subsp. *rosetta*), which was moved down by Cormaci et al. (1992) to a forma. For Garreta et al. (2001) the f. *rosetta* is regarded as a synonym of *C. compressa*, since in the Iberian Peninsula the autumn and winter plants from sheltered places display a bearing similar to those from exposed locations.

According to Garreta et al. (2000), the phenological cycle of our specimens is characterized by the succession of two dominant and well-distinguishable forms: a winter rosette-shaped one, with short primary branches, and a spring one, more luxuriant with erect fronds (Fig. 4). The morphological characteristics of sampled thalli partially coincide with those described by Huvé (1972) for the sheltered stations in the North-West Mediterranean, even if our samples were collected in a site with elevated hydrodynamism. If compared with the Gómez et al. (2000) measures, in the Gulf of Trieste the lengths of the thalli show in spring-summer intermediate values between the ones reported for the exposed and sheltered locations. Since we collected thalli only at a single site, future research will require comparable estimates among systems with different regimes of hydrodynamism and disturbance, in order to bear out the phenological cycle and the eventual coexistence of the two forms in both sheltered and exposed conditions.

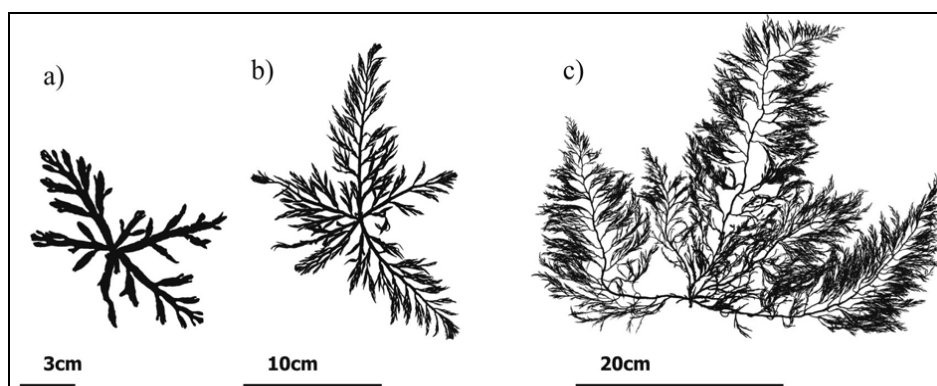


Fig. 4: Dominant phenological phases of *C. compressa* in the studied area (digitalized images).

Sl. 4: Prevladujoče fenološke faze *C. compressa* v preučevanem območju (digitalizirane slike).

To a large extent, the thallus's overall length at its maximum height depends on the length of the I branches and to a lower extent on those of the II branches. Furthermore, the morphological changes are characterized by a marked variation in the diameter of the branches. In winter, when the photoperiod length is shorter, the thallus seems to present a mechanomorphic adaptation that determines the presence of broad flattened branches, which offer a larger surface to the radiant flux.

Studies on growth and reproduction result to be particularly important for a wider understanding on the abundance and distribution of the species, and therefore on the community structure, also with the aim of environmental restoration and mitigation actions in partially

degraded areas (Celan & Bavaru, 1978; Falace & Bressan, 2004).

Finally, frond morphology variations are determinant in order to define the structural complexity of the thallus architecture, which in turn involves a wider diversification and heterogeneity of the habitat, additional substratum and ecological gradients for the epibionts (Falace & Bressan, 2004; Falace & Bressan, *in press*; Piani et al., 2004).

ACKNOWLEDGEMENTS

We are very grateful to Drs. M. Cuzziol, E. Borgese and S. Limina for their helpful assistance in the field work.

MORFOLOŠKA IN RAZMNOŽEVALNA FENOLOGIJA VRSTE *CYTOSEIRA COMPRESSA* (ESPER) GERLOFF & NIZAMUDDIN (FUCALES, FUCOPHYCEAE) V TRŽAŠKEM ZALIVU (SEVERNI JADRAN)

Annalisa FALACE, Elisa ZANELLI & Guido BRESSAN

Università degli Studi di Trieste, Dipartimento di Biologia, I-34127 Trieste, Via L. Giorgieri 10, Italy

E-mail: falace@univ.trieste.it

POVZETEK

Med preučevanjem splošnih značilnosti populacij iz rodu *Cystoseira* je bilo ugotovljeno, da so raziskave, ki zadevajo njihovo rast in razmnoževanje, še posebno pomembne za poznavanje številčnosti, razširjenosti in sestavo združbe. To je pomembno tudi z vidika ohranjanja okolja ali lajšanja posledic v delno degradiranih območjih. O morfološki in razmnoževalni fenologiji vrste *Cystoseira compressa* je na voljo le nekaj podatkov. Z namenom, da bi v severnem Jadranu definirali variabilnost diaktričnih značilnosti te vrste in ocenili sezonsko periodičnost rasti in razmnoževanja, so avtorji prispevka v Izoli opravili temeljito študijo. V letu dni so vsak mesec naključno vzeli 6 steljk te vrste in izmerili morfometrične parametre vsakega vzorca. Na tej podlagi so opisali morfološko variabilnost steljke in fenološki cikel, za katerega je značilna sukcesija dveh prevladujočih form.

Ključne besede: *Cystoseira compressa*, fenologija, morfologija, Tržaški zaliv, severni Jadran

REFERENCES

- Aarnio, K. & J. Mattila (2000):** Predation by juvenile *Platichthys flesus* (L.) on shelled prey species in a bare sand and a drift algae habitat. *Hydrobiologia*, 440, 347–355.
- Aioldi, L. (2003):** The effects of sedimentation on rocky coasts assemblages. *Oceanogr. Mar. Biol.*, 41, 161–236.
- Alongi, G., M. Catra & M. Cormaci (1999):** Fenologia morfologica e riproduttiva di *Cystoseira elegans* Sauvageau (Cystoseiraceae, Phaeophyta). *Boll. Acc. Gioenia Sci. Nat.*, 31(354), 189–199.
- Amico, V. (1995):** Marine Brown algae of family Cystoseiraceae: chemistry and chemotaxonomy. *Phytochemistry*, 39(6), 1257–1279.
- Amico, V., G. Giaccone, P. Colombo, P. Colonna, A. M. Mannino & R. Randazzo (1985):** Un nuovo approccio allo studio della sistematica del genere *Cystoseira* C. Agardh (Phaeophyta, Fucales). *Boll. Acc. Gioenia Sci. Nat.*, 18(326), 887–986.
- Ballesteros, E. (1988):** Estructura y dinámica de la comunidad de *Cystoseira mediterranea* Sauvageau en el Mediterráneo Noroccidental. *Inv. Pesq.*, 52, 313–334.
- Barcelo, M.C. & J.A. Seoane Camba (1984):** Nota sobre la variación fenológica de *Cystoseira sauvageauana* Hamel en las costas de Alicante. *Anales Biol.*, 2, 45–54.
- Beleggratis, M. R. & I. Bitis (1989):** Epiphytic patterns of macroalgal assemblages on *Cystoseira* species (Fucales, Phaeophyta) in the east coast of Attica (Aegean Sea, Greece). *Hydrobiologia*, 412, 67–80.

- Benedetti-Cecchi, L., F. Pannacciulli, F. Bulleri, P. S. Morchella, L. Airoidi, G. Relini & F. Cinelli (2001):** Predicting the consequences of anthropogenic disturbance: large-scale effects of loss of canopy algae on rocky shores. *Mar. Ecol. Prog. Ser.*, 214, 137–150.
- Bertuzzi A., J. Fagnani & A. Brambati (1996):** Annual variation of benthic nutrient fluxes in shallow coastal waters (Gulf of Trieste, northern Adriatic Sea). *P.S.Z.N. I: Mar. Ecol.*, 17, 261–278.
- Boudouresque, C. F. (1971):** Contribution à l'étude phytosociologique des peuplements algaux des côtes varoises. *Vegetatio*, 22, 83–184.
- Celan, M. & A. Bavaru (1978):** Sur l'état actuel de la végétation algale du littoral roumain de la Mer Noire. *Cercetări marine, IRCM*, 11, 85–90.
- Cormaci, M. & G. Furnari (1999):** Changes of the benthic algal flora of the Tremiti Islands (Southern Adriatic) Italy. *Hydrobiologia*, 398/399, 75–79.
- Cormaci, M., G. Furnari, G. Giaccone, B. Scammacca & D. Serio (1992):** Observations taxonomiques et biogéographiques sur quelques espèces du genre *Cystoseira* C. Agardh. *Bull. Institut. Océanographique, Monaco*, 9, 21–35.
- Dean, R. L. & J. H. Connell (1987):** Marine invertebrates in an algal succession. III. Mechanisms linking habitat complexity with diversity. *J. Exp. Mar. Biol. Ecol.*, 109, 249–273.
- Ercegović, A. (1952):** Jadranske cistozire. Fauna i flora Jadrana, Kn. 2. Split, 212 pp.
- Falace, A. (2000):** Variazioni fisionomiche spaziotemporali della vegetazione sommersa del Golfo di Trieste: analisi delle principali influenze ambientali. Ph.D. Thesis. University of Trieste, Trieste, 102 pp.
- Falace A. & G. Bressan (2003):** Changes of algal flora in the Gulf of Trieste (Northern Adriatic Sea). *Boccone*, 16(2), 1033–1037.
- Falace, A. & G. Bressan (2004):** Intervento pilota di restauro biologico mediante tecniche di trapianto algale. *Biol. Mar. Medit.*, 11(2), 449–503.
- Falace, A. & G. Bressan (in press):** Seasonal variations of *Cystoseira barbata* (Stackhouse) C. Agardh frond architecture. *Hydrobiologia*. (in press)
- Falace, A., A. Di Pascoli & G. Bressan (in press):** Valutazione della biodiversità nella Riserva Marina di Miramare (Nord Adriatico): macroalghe marine bentoniche. *Biol. Mar. Medit.* (in press)
- Figueiredo, O. M. A., J. M. Kain & T. A. Norton (2000):** Responses of crustose corallines to epiphyte and canopy cover. *J. Phycol.*, 1, 17–24.
- Firsov, Y. K. & K. M. Khailov (1979):** Morphophysiological analysis of the hierarchical structure of *Cystoseira barbata* thalli. *Bot. Mar.*, 22, 333–345.
- Furnari, G., G. Giaccone, M. Cormaci, G. Alongi & D. Serio (2003):** Biodiversità marina delle coste italiane: catalogo del macrofitobenthos. *Biol. Mar. Medit.*, 10(1), 482 pp.
- Giaccone, G. (1973):** Ecologie et chorologie des *Cystoseira* de Méditerranée. *Rapp. Comm. Int. Mer Médit.*, 22(4), 49–50.
- Giaccone, G. (1991):** Biogeografia di alghe brune e tettonica a zolle. *Boll. Acc. Gioenia Sci. Nat.*, 24(337), 65–86.
- Giaccone, G. & A. Bruni (1971):** Le *Cystoseira* delle coste italiane. I. Contributo. *Ann. Univ. Ferrara (N.S.)*, Ser. IV, Bot., 4(3), 45–70.
- Giaccone, G. & A. Bruni (1973):** Le *Cystoseira* e la vegetazione sommersa del mediterraneo. *Atti Ist. Ven. Sci. Lett. Arti*, 131, 59–103.
- Giaccone, G. & G. Motta (1987):** Le *Cystoseira*: sistematica, fitogeografia, utilizzazione. *Atti Conv. Naz. "Alghe e loro utilizzazione"*. Camera di Commercio, Lecce, p. 65–74.
- Gòmez, A., M. A. Ribera & J. A. Seoane Camba (1982):** Estudio fenológico de varias especies del género *Cystoseira* en Mallorca. *Collectanea Botanica*, 13(2), 841–855.
- Gòmez-Garreta, A. (2000):** Flora Phycologica Iberica. 1. Fuciales. Universidad, Servicio de Publicaciones. Universidad de Murcia, 192 pp.
- Hamel, G. (1939):** Phéophycées de France. 5. Dictyotacées-Sargassacées. Paris, p. 418–421.
- Hawkins, S. J. (1983):** Interaction of *Patella* and macroalgae with settling *Balanus balanoides* (L.). *J. Exp. Mar. Biol. Ecol.*, 71, 55–72.
- Hernández-Carmona, G., O. García, D. Robledo & M. Foster (2000):** Restoration techniques for *Macrocystis pyrifera* (Phaeophyceae) populations at the Southern limit of their distribution in México. *Bot. Mar.*, 43, 273–284.
- Hicks, G. R. F. (1980):** Structure of phytal harpacticoid Copepod assemblages and the influence of habitat complexity and turbidity. *J. Exp. Mar. Biol. Ecol.*, 44, 157–192.
- Hoffmann, L., R. Renard & V. Demoulin (1992):** Phenology, growth and biomass of *Cystoseira balearica* in Calvi (Corsica). *Mar. Ecol. Prog. Ser.*, 80, 249–254.
- Huvé, H. (1972):** Aperçu sur la distribution en mer Egée de quelques espèces du genre *Cystoseira* (Phéophycées, Fuciales). *Bull. Soc. Phycol. Fr.*, 17, 22–37.
- Jenkins, S. R., T. A. Norton & S. J. Hawkins (1999):** Settlement and post-settlement interactions between *Semibalanus balanoides* (L.) (Crustacea: Cirripeda) and three species of furoid canopy algae. *J. Exp. Mar. Biol. Ecol.*, 236, 49–67.
- Jones, C. G., J. H. Lawton & M. Shachak (1994):** Organisms as ecosystem engineers. *Oikos*, 69, 373–386.
- Kennelly, S. J. (1989):** Effects of kelp canopies on understory species due to shade and scour. *Mar. Ecol. Prog. Ser.*, 50, 215–224.
- Khailov, K. M. (1978):** Changes in the mass, length and metabolism of simple and composite thalli of marine macrophytes in their ontogenic series. *Bot. Mar.*, 21, 313–321.

- Khailov, K. M. (1979):** Ontogenic trends in morphologic parameters of *Cystoseira barbata* thalli. Bot. Mar., 22, 299–311.
- Khailov, K. M & Yu. K. Firsov (1979):** The relationships between weight, length, age and intensity of photosynthesis and organotrophy in the thallus of *Cystoseira barbata* from the Black Sea. Bot. Mar., 19, 329–334.
- Marzocchi, M., D. Curiel, C. Dri & M. Scattolin (2003):** Fenologia morfologica e riproduttiva di *Cystoseira barbata* (Stackhouse) C. Agardh v. *barbata* (Fuciales, Fucophyceae) nella laguna di Venezia (Nord Adriatico). Soc. Veneziana Sci. Nat., 28, 21–23.
- McCook, L. J. & A. R. O. Chapman (1991):** Community structure following massive ice scour on an exposed rocky-shore: effects of *Fucus* canopy algae and of mussels during late succession. J. Exp. Mar. Biol. Ecol., 154, 137–169.
- Melville, A. J. & S. D. Connell (2001):** Experimental effects of kelp canopies on subtidal coralline algae. Aust. Ecol., 26, 102–108.
- Menge, B. A. (1978):** Predation intensity in a rocky intertidal community. Relation between predator foraging activity and environment harshness. Oecologia, 34, 1–16.
- Montesanto, B. & P. Panayotidis (2001):** The *Cystoseira* spp. communities from the Aegean Sea (NE Mediterranean). Medit. Mar. Sci., 2(1), 57–67.
- Mosetti, F. (1972):** Alcune ricerche sulle correnti del Golfo di Trieste. Riv. Ital. Geofis., 21, 33–38.
- Motta, G. (1989):** Fenologia morfologica e riproduttiva di *Cystoseira sauvageauana* Hamel (Phaeophycophyta, Fuciales). Boll. Acc. Gioenia Sci. Nat., 22, 317–334.
- Munda, I. (1991):** Algal resources in polluted sites of the Northern Adriatic (vicinity of Piran). Acta Adriat., 32, 682–704.
- Munda, I. (1993a):** Changes and degradation of seaweed stands in the Northern Adriatic. Hydrobiologia, 260/261, 239–253.
- Munda, I. (1993b):** Impact of pollution on benthic marine algae in the Northern Adriatic. Int. J. Environ. Stud., 43, 185–199.
- Munda, I. (2000):** Long-term marine floristic changes around Rovinj (Istrian coast, North Adriatic) estimated on the basis of historical data from Paul Kuckuck's field diaries from the end of the 19th century. Nova Hedwigia, 71, 1–36.
- Ogorelec, B., M. Mišič & J. Faganeli (1991):** Marine geology of the Gulf of Trieste (northern Adriatic): sedimentological aspects. Mar. Geol., 99, 79–82.
- Oliveras, M. A. & A. Gòmez-Garreta (1989):** Corologia del género *Cystoseira* C. Agardh (Phaeophyceae, Fuciales). Anales jardin Botánico de Madrid, 46(1), 89–97.
- Otero-Schmitt, J. & J. L. Pérez-Cirera (1996):** Epiphytism on *Cystoseira* (Fuciales, Phaeophyta) from the Atlantic Coast of Northwest Spain. Bot. Mar., 39, 445–465.
- Paine, R. T. (1969):** A note on trophic complexity and community stability. Am. Nat., 103, 91–93.
- Piani, R., E. Zanelli & A. Falace (2004):** Characterization of the suspended matter trapped by different morphological groups of algae. Proc. 39th EMBS. 21–24 July, 2004, Genova, Italy.
- Piattelli, M. (1990):** Chemistry and taxonomy of Sicilian *Cystoseira* species. New J. Chem., 14, 777–782.
- Pizzuto, F. (1998):** Fenologia morfologica e riproduttiva di *Cystoseira crinita* Duby (Fuciales, Fucophyceae) di Isola delle Correnti (Siracusa, Italia). Boll. Acc. Gioenia Sci. Nat., 30(353), 129–136.
- Reed, D. C. & M. S. Foster, 1984.** The effect of canopy shading on algal recruitment and growth in a giant kelp forest. Ecology, 65, 937–948.
- Ribera, M. A., A. Gòmez-Garreta, M. C. Barcelò & J. Rull Lluch (1995):** Mapas de distribucion de algas marinas de la Peninsula Iberica e islas Baleares. VIII. *Cystoseira* C. Agardh y *Sargassum* C. Agardh. Bot. Complutensis, 20, 89–103.
- Ribera, M. A., A. Gòmez-Garreta, T. Gallardo, M. Cormaci, G. Furnari & G. Giaccone (1992):** Check-list of Mediterranean seaweeds. I. Fucophyceae (Warming, 1884). Bot. Mar., 35(2), 109–130.
- Roberts, M. (1978):** Active speciation in the taxonomy of the genus *Cystoseira* C. Ag. In: Irvine, D. E. G & J. H. Price (eds.): Modern approach to the taxonomy of the Red and Brown algae. Acad. Press, London, p. 399–422.
- Rull, L. & A. Gòmez-Garreta (1990):** Estudio de la comunidad de *Cystoseira mediterranea* en dos localidades de la península del cabo de Creus (Alt Empordà, Nordeste de España). Collect. Bot., 18, 5–19.
- Savaugau, C. (1912):** A propos des *Cystoseira* de Banyuls et de Guéthary. Bull. Stat. Biol. Archachon, 14, 133–556.
- Serio, D. (1995):** Fenologia morfologica e riproduttiva di *Cystoseira spinosa* Sauvageau v. *compressa* (Ercegovic) Cormaci et al. (Fuciales, Fucophyceae). Boll. Acc. Gioenia Sci. Nat., 28(349), 5–22.
- Sfriso, A., A. Marcomini, B. Pavoni & A. A. Orio (1993):** Species composition, biomass, and net primary production in shallow coastal waters: the Venice Lagoon. Bioresour. Technol., 44, 235–250.
- Tigànus, V. (1972):** Ecological observations on the fauna associated to the *Cystoseira* belt along the Romanian Black Sea Coast. Cercetări marine, IRCM, 4, 153–167.
- UNEP (1996):** The state of the marine and coastal environment in the Mediterranean region. MAP Technical Report Series, 100, 142 pp.
- Valiante, A. (1883):** Le *Cystoseirae* del Golfo di Napoli. Fauna et Flora Golf. Neapol., 7, 1–30.
- Zore Armanda, M. & M. Gačić (1987):** Effects of bora on the circulation in the North Adriatic. Ann. Geophys., 56, 93–121.

original scientific article
received: 2005-05-30

UDC 574.4/.5:581.9(497.4 Strunjan)

VEGETATION OF THE STJUŽA COASTAL LAGOON IN STRUNJAN LANDSCAPE PARK (SLOVENIA): A DRAFT HISTORY, MAPPING AND NATURE-CONSERVANCY EVALUATION

Nina ŠAJNA

University of Maribor, Pedagogical Faculty, Department of Biology, SI-2000 Maribor, Koroška 160
E-mail: nina.sajna@uni-mb.si

Mitja KALIGARIČ

Department of Biology, Pedagogical Faculty, University of Maribor, SI-2000 Maribor, Koroška 160
University of Primorska, Science and Research Centre of Koper, Institute for biodiversity studies, SI-6000 Koper, Garibaldijska 1

ABSTRACT

*A draft history of the artificial Stjuža coastal lagoon was reconstructed on the basis of old maps (1804 and 1873) and compared with the present-day situation using GIS. The current data were simplified to obtain comparable categories (landscape units) with old maps. The following major landscape units were distinguished: lagoon, salt marshes, mainland, brackish rivers and estuaries, ditches and canals, salt-pans, embankment, villages and roads. On current map, a total of 47 habitat types according to PHYSIS typology occurring in 206 polygons, which cover an area of 41.6 ha, were identified and described. Habitats with greater nature-conservancy value cover 26.7 ha of the total research area and constitute 40% of the polygons described. 55.6% of these belong to halophilous scrubs – *Sarcocornetea fruticosi* (= *Arthrocnemetea fruticosi*) – and 25.9% to annual salt pioneer sward communities, dominated by *Salicornia europaea*. Mediterranean salt swamps (*Juncion maritimi*) are present to a small extent only. It could be concluded that the artificial Stjuža lagoon, constructed for fish farming purposes, developed in habitat diverse coastal wetland area after partial abandonment.*

Key words: coastal lagoon, vegetation, habitat types, PHYSIS, mapping GIS

VEGETAZIONE DELLA LAGUNA COSTIERA STJUŽA NEL PARCO NATURALE DI STRUGNANO (SLOVENIA): BOZZA STORICA, RILEVAMENTO E VALUTAZIONE DEL GRADO DI CONSERVAZIONE DELLA NATURA

SINTESI

*Sulla base di vecchie mappe (datate 1804 e 1873) gli autori hanno ricostruito una bozza storica della laguna costiera artificiale Stjuža e, con l'ausilio del GIS, l'hanno confrontata con la situazione attuale. I dati recenti sono stati semplificati per ottenere categorie comparabili (unità di terreno) con le vecchie mappe. Le nove maggiori unità distinte comprendono: laguna, maremme, terraferma, fiumi ed estuari salmastri, fossi e canali, saline, argini, villaggi e strade. Sulla mappa contemporanea vengono identificati e descritti 47 tipi di habitat conformi alla tipologia PHYSIS, ritrovabili in 206 poligoni, ricoprenti un'area di 41,6 ettari. Gli habitat con il più alto grado di conservazione della natura ricoprono 26,7 ettari dell'area studiata, ovvero il 40 % dei poligoni descritti. Il 55,6 % di essi appartiene ad arbusti alofili – *Sarcocornetea fruticosi* (= *Arthrocnemetea fruticosi*) – mentre il 25,9 % alle comunità annuali pioniere alofile, dominate da *Salicornia europaea*. Le caratteristiche maremme mediterranee (*Juncion maritimi*) sono presenti solo in minor misura in quest'area. Gli autori concludono che la laguna artificiale Stjuža ha sviluppato, dopo un parziale abbandono dell'attività di piscicoltura, diversi habitat tipici delle zone umide costiere.*

Parole chiave: laguna costiera, vegetazione, tipi di habitat, PHYSIS, rilevamento, GIS

INTRODUCTION

The area under consideration was declared Strunjan Nature Park in 1990 (Firbas, 2001), primarily due to its floristic and faunistic diversity, geological phenomena and landscape value. The attractive seacoast cliffs are built of flysch (Eocene calcareous sandstone), which enables development of deciduous thermophilous vegetation. Due to flysch properties (impermeable to water), there are several springs and most of them remain active also during the summer. The most prominent among them is the Strunjan stream, even though it is only 5.6 km long but, except that in its lower course the permanent water input is provided with underground springs (Radinja, 1979). In its mouth in Strunjan bay there probably was, in pre-human history, a seacoast marsh, developed on alluvial deposits. We could assume that *Phragmites* and *Juncus maritimus*-dominated vegetation developed in permanently flooded stands. Halophyte vegetation probably developed on shallow mudflats of the estuary in different forms, mostly due to the salinity level, water availability, soil type and microtopography. The area, however, must have been subjected to strong human pressures in distant past. As early as in Roman times (Darovec, 1992), the sedimentary coast of the mouth of the Strunjan stream was probably transformed into salt-pans, which still exist nowadays. Another part of the bay was later separated from the sea by a shallow dyke, but remained connected with a canal. It was used for fish farming, but abandoned at the beginning of the 20th century (Avčin *et al.*, 1974). As the lagoon originated due to the fact that the bay was artificially closed and separated from the open sea, it was given the name Stjuža, deriving from the Italian term "chiusa" (closed).

Marine environments, like estuaries and lagoons, constitute highly productive ecosystems with special ecological role owing to their location between marine and terrestrial interface area, where nutrients are supplied from fresh water inputs, tides, the atmosphere and bottom sediments (Forman & Godron, 1986). Still, they remain among the most threatened ecosystems worldwide according to IUCN classification, especially due to various anthropogenic impacts, such as tourism activities, aquaculture and agriculture (Salman, 1994).

Today, the Stjuža coastal lagoon is an important wetland site also due to the rare and endangered halophyte vegetation types and its halophyte flora. Ample data on the halophyte flora of Strunjan were available already in some historical floras, such as Marchesetti (1896-97) and Pospichal (1897-98). A very comprehensive list was produced by Wraber (1974) and later completed by Kaligarič (1996). The vegetation cover, threat status and phytocoenosis distribution of halophytes have been discussed by Kaligarič (1985, 1996, 1999a, 1999b), with phytosociological Strunjan relevés also included in Poldini *et al.* (1999).

The objective of this study was (1) to make a draft historical reconstruction of the area's vegetation assemblage, (2) to quantify and spatially characterise the present vegetation throughout habitat types, (3) to identify valuable habitats for conservation, and (4) to develop a GIS system that can be used for future observations.

MATERIAL AND METHODS

Cartography

The early available vegetation covers of the area were interpreted from Austro-Hungarian military maps, made in 1804 exclusively for military purposes within the "Emperor Joseph II Land Survey" (Rajšp & Ficko, 1996). The maps were drawn at a scale of ca. 1 : 28,000. They are not sufficiently accurate to be processed directly by GIS (Čarni *et al.*, 1998), but by comparing the positions and distances between still existing single houses from old and new maps, it was possible to transfer categories, clearly visible from the old maps, into GIS and allowed us to resize the maps to fit the scale of the present ones.

Next temporal window is represented by Italian cadastre ("Regolazione dell'imposta fondiaria") at a scale of ca. 1 : 20,000, drawn in 1873 by Giuseppe Coreggi (Coreggi, 1873). The lagoon is marked "Peschiera di Strugnano Basso" and "Pesca", with both names referring to fish farming.

The current data were simplified to obtain comparable categories (landscape units) with old maps. We distinguished the following major habitat categories: lagoon, salt marshes, mainland, brackish rivers and estuaries, ditches and canals, salt-pans, embankment, villages and roads.

Habitat mapping

To represent the diversity of various biological features, different approaches are used. Diversity can be measured either at the species or community levels (Boteva *et al.*, 2004). A survey at the species level could be very complex and time-consuming, like a detailed floristic and faunistic inventory. Remote-sensing data, like airborne methods, require field evaluation to prevent different kinds of errors associated with digitising and subjective photo interpretation (Green & Hartley, 2000). Sometimes the scale is not sufficiently accurate, especially if the vegetation occurs in a small-structured mosaic, like the Stjuža coastal lagoon. Smith & Theberge (1986) emphasize that vegetation communities are the most commonly used spatial unit for diversity assessment. As suggested by Kati *et al.* (2004), standard typologies of habitats, predominantly based on vegetation types, according to Devillers & Devillers-Terschuren (1996), Pienkowski *et al.* (1996) or Stoms *et al.* (1998),

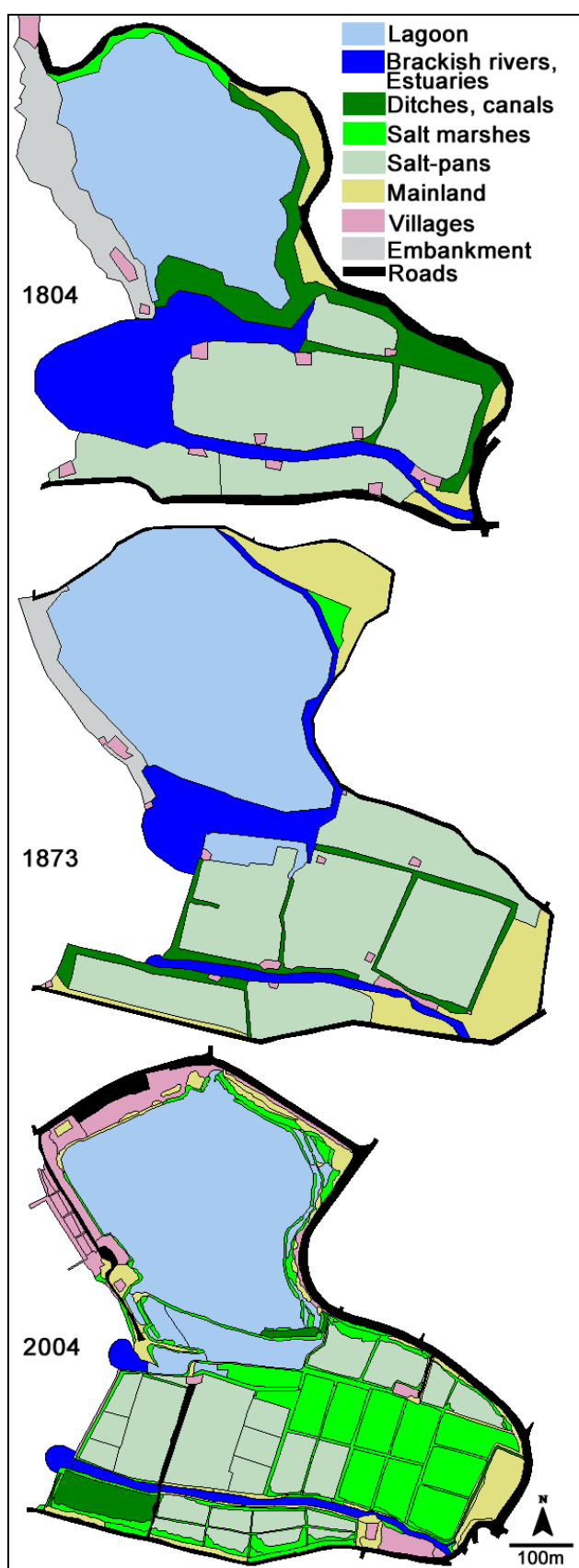


Fig. 1: Historical review of the Stjuža lagoon and adjoining areas on the basis of 10 landscape units.

Sl. 1: Zgodovinski pregled lagune Stjuža in sosednjih območij na podlagi 10 krajinskih enot.

could be used effectively. Among them PHYSIS is very practical, due to its physiognomically based criteria of determining single polygons, but its units are phytosociologically grounded. PHYSIS Data Base (Devilliers & Devilliers-Terschuren, 1996) was adapted and improved in order to fit local conditions (Jogan *et al.*, 2004).

Therefore, we evaluated the current situation by field observations combined with aerial photographs (digitalized ortho-photographs, provided by GURS, Republic of Slovenia). For elaboration in GIS, the computer package ArcView 3.1 (ESRI) was used. Field data included habitat types classified according to Palaearctic habitat typology from PHYSIS Data Base, adjusted to Slovenian habitat characteristics.

To obtain more precise description of habitats occurring in the field, we used intermediates (marked with "x") between two habitat types in case of transition between two habitat types. For the same purpose we used a combination of two habitat types marked with "/", when trying to explain one type with the help of another (for instance forest fragment explained with the type of the forest).

For the identification of habitat units with greater nature-conservancy value (App. 1), we used the list of priority habitats ("FFH" code that corresponds to the NATURA 2000 code) from the Annex I of the "Habitats Directive" (Directive 92/43/EEC, 1992).

To reduce the level of details that cannot be show on 1 : 6,000 maps, we aggregated related habitat types into 15 categories (App. 1) and named them adequately (Tab. 1).

Each map produced was processed via detailed quality control check with CLU Quality Control extension in ArcView, to clear the multipart polygons, overlapping polygons, sliver polygons, void polygons and adjacency. Obtained spatial data is geolocated and can now be stored and visualized using geographic information systems (GIS).

Tab. 1: Codes and names for different aggregate types derived from PHYSIS typology.**Tab. 1: Kode in imena zbirnih habitatnih tipov na podlagi tipologije PHYSIS.**

Aggregate code used in Fig. 2	Name of the aggregate
1	Marine communities Open-water and bottom communities and vascular vegetation beds; marine communities of the littoral zone and coastal lagoons.
2	River mouths, estuaries and mudflats River mouths, estuaries, sand or mud sea banks under influence of tide.
3	Glasswort swards Annual salt pioneer swards, in particular <i>Salicornia herbacea</i> , colonizing periodically inundated mud of the Mediterranean coastal saltmarshes.
4	Tall rush saltmarshes Beds of <i>Juncus maritimus</i> or <i>J. acutus</i> of periodically inundated depressions of the Mediterranean. In Slovenia, only <i>J. maritimus</i> occurs.
5	Saltmarsh scrubs and rocky shore communities Low shrubby expanses of woody halophytes, characteristic of inundated saltmarshes and rocky shores with several annual plants.
6	Coastal lagoons Saline or hypersaline waters cut off from the sea completely or still connected to the sea by narrow passages. The presence of marine invertebrate communities or vegetation can be indicated by addition of other habitat codes.
7	Ligneous formations Ligneous formations of natural thermophilous shrub communities or cultivated tree formations composed of native, exotic or native species out of their natural range and habitat.
8	Reed beds Communities of the margins of lakes, sea inlets, rivers and brooks, eutrophic marshes, swamps, ditches dominated by tall Poaceae-like <i>Phragmites</i> .
9	Ruderal communities Communities of pioneering, introduced or nitrophilous plants colonising waste places, disturbed natural or seminatural areas, roadsides and other interstitial spaces or disturbed ground.
10	High-stem orchards Tree crops of standards, cultivated for fruit production.
11	Urban green spaces Usually varied formations, created for recreational use. The vegetation usually composed mainly of introduced species or cultivars.
12	Towns, villages, industrial sites Areas used for human occupation and industrial activities.
13	Salt-pans Active or recently abandoned salt-extraction basins. When vegetation is established, detailed habitats can be specified by means of the subdivisions of 15.
14	Ditches and small canals Narrow linear artificial freshwater bodies, mostly used for irrigation or partition, in this case for the purpose of salt-extraction basins.
15	Roads

RESULTS AND DISCUSSION

Slovenia has a very short coastline of 47 km (Kos, 1996), whose greater part is composed of a fairly steep coast (including an 80 m high cliff formation). Despite its artificial origin, the Stjuža lagoon developed into diversity-rich habitats of great ecological importance.

A draft historical reconstruction

There were no maps, transferable to GIS, available before the beginning of the 19th century. Therefore, there are no cartographic records of the earlier mentioned open bay. On the Austro-Hungarian military map, however, the embankment seems to be of relatively recent origin if we look at the shape of the dyke and the green

coloration on the original map. The halophyte and brackish swamp vegetation began to develop when the lagoon was closed, and due to hydrologic dynamics, sediment deposition and anthropogenic impact, the vegetation cover continuously followed these dynamics. The cartographic aspect of the vegetation cover, simplified in order to be comparable, is shown in three temporal windows in figure 1. A review of the historical data shows that the area of brackish rivers, estuaries and salt marshes became shrank during the centuries, whereas the salt-pans expanded towards the sea. Nowadays, the increasingly occurring saltmarshes favours salt-pans abandonment. Also, the size and shape of the lagoon has varied through history. In 1873, the lagoon was the largest, almost twice the present size with its total surface area of 10.55 ha. In general, it is well known that species diversity correlates with habitat size, but in

habitats that include shoreline, the shape is significant as well. To describe the changes occurring in the shape of the lagoon, we calculated an index according to Forman & Godron (1986). It is the ratio between shore length and the circumference of a circle with same surface area as the water body that can describe the degree of development of the shoreline (D). In 1804, the shoreline development values were higher ($D = 1.317$), the dyke and the lagoon had a more natural appearance. The smallest values were calculated for the year 1873 ($D = 1.130$), despite the large surface area. This leads back to an intense fish farming activity at the time. Nowadays, the degree of the lagoon shoreline development increased ($D = 1.283$) due to abandonment of fish farming and assemblage of marginal vegetation (saltmarsh scrub, reed beds and ruderal communities).

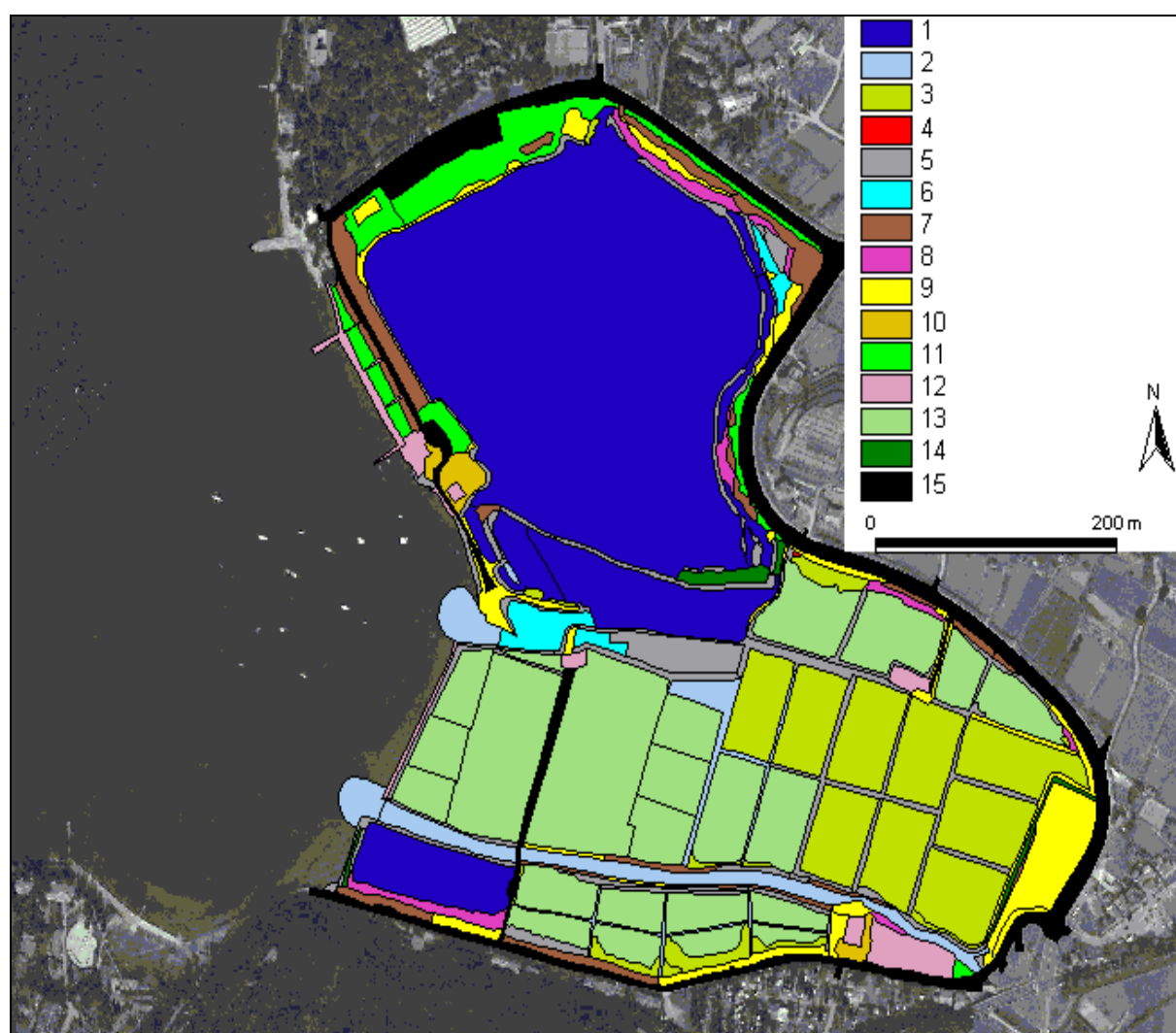


Fig. 2: 15 aggregated habitat types (see Table 1) of the Stjuža lagoon and adjoining areas.
Sl. 2: 15 zbirnih habitatnih tipov (glej Tabelo 1) lagune Stjuža in sosednjih območij.

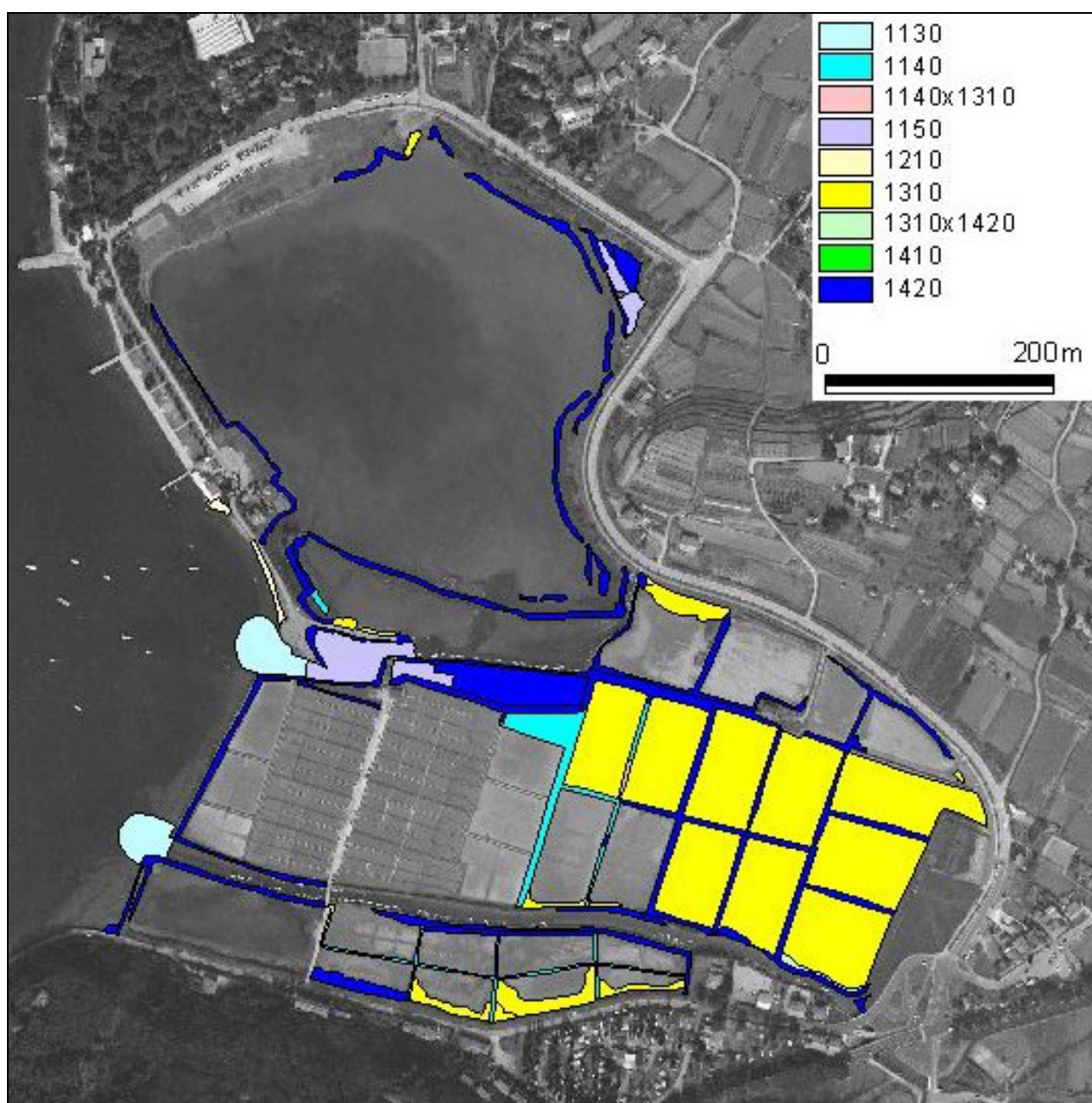


Fig. 3: Habitat types of greater nature-conservancy value ("Natura 2000 habitats") of the Stjuža lagoon and adjoining areas. For names of the habitats see App. 1.

Sl. 3: Naravovarstveno pomembnejši habitatni tipi ("habitati Natura 2000") lagune Stjuža in sosednjih območij. Za imena habitatnih tipov glej App. 1.

Habitat mapping

We identified and described a total of 47 habitat units according to PHYSIS typology occurring in 206 polygons that cover an area of 41.6 ha. The current situation of aggregated habitat types is shown in figure 2. It is a remarkable complex of coastal and halophytic habitats present in a small area, although some polygons show consider-

able size. Most of the area is occupied by seagrass meadows with *Cymodocea* and *Zostera* (13.6 ha), although we found *Ruppia cyrrhosa* in a single small polygon (0.8 ha) as well. Areas with extensive salt-extraction activities occupy 10 ha. The cover area is followed by ruderal communities (3.8 ha) and glasswort swards with annual *Salicornia*, *Suaeda* or *Salsola* on 2.35 ha.

We introduced a new habitat type category for Slo-

vene PHYSIS classification – Tamarisk stands, due to the subspontaneous abundant formations in areas that cannot be avoided at this mapping scale. Large part of the mapped habitat is covered by ruderal communities or their intermediates. This is a sign of unstable and disturbed habitats, though very floristically rich due to warm climatic conditions at Strunjan.

Habitats with greater nature value (Fig. 3) cover 26.7 ha of the total research area, constituting 40 % of the polygons described. Almost all halophytic habitat types known for Slovenia and classified as priority habitats by the Habitats directive are present there. Among these habitat types, 55.6 % are represented by habitats suitable for halophilous scrubs – *Sarcocornetea fruticosi* (FFH code number 1420), occurring mainly in the abandoned salt-pan basins, and 25.9 % habitats by annual salt pioneer swards communities, in particular with dominating *Salicornia europaea*, often the only species in

the community, colonising periodically inundated sand and silt banks (code 1310). These communities require soil with high ion concentration and low oxygen availability, as well as gently sloping sea banks protected from direct impact of the sea for their establishment (Kaligarič, 1996) that can be found in the abandoned salt-pans and at the edges of some still active salt-extraction basins. Mediterranean salt meadows (*Juncion maritimi*) are present to a minor extent, likewise the annual halophytes colonising the rocky shores.

It could be concluded that this is the only lagoon on the Slovenian flysch and flysch-derived sedimentary coast, despite being artificially developed in habitat-diverse and halophyte communities-rich coastal wetland area. Historical reconstruction of the past 200 years indicates that the assemblage of valuable habitats increased, probably due to partial abandonment of salt-pans and fish farming activities.

VEGETACIJA OBALNE LAGUNE STJUŽA V KRAJINSKEM PARKU STRUNJAN (SLOVENIJA): ZGODOVINSKI ORIS, KARTIRANJE IN NARAVOVARSTVENO OVREDNOTENJE

Nina ŠAJNA

Univerza v Mariboru, Pedagoška fakulteta, Oddelek za biologijo, SI-2000 Maribor, Koroška 160
E-mail: nina.sajna@uni-mb.si

Mitja KALIGARIČ

Univerza v Mariboru, Pedagoška fakulteta, Oddelek za biologijo, SI-2000 Maribor, Koroška 160
Univerza na Primorskem, Znanstveno-raziskovalno središče Koper, Inštitut za biodiverzitetne študije, SI-6000 Koper, Garibaldijeva 1

POVZETEK

Avtorja sta na osnovi starih zemljevidov (1804 in 1873) napravila rekonstrukcijo lagune Stjuža v Strunjanu in jo ob pomoči GIS (geografskega informacijskega sistema) primerjala z današnjo. Z namenom, da bi dobila s starimi zemljevidi primerljive kategorije (krajinske enote), sta poenostavila današnje podatke in določila naslednje glavne krajinske enote: laguno, slanišča, kopno, brakične reke in ustja, jarke in kanale, soline, nasip, vasi in ceste. Na današnjem zemljevidu sta identificirala in opisala skupaj 47 habitatnih tipov glede na tipologijo PHYSIS, ki se pojavljajo na 206 poligonih na površini 41,6 ha. Naravovarstveno pomembnejši habitatni tipi se raztezajo na 26,7 ha celotne raziskane površine in sestavljajo 40 % opisanih poligonov. 55,6 % od teh pripadajo slanljubemu grmišču – *Sarcocornetea fruticosi* (= *Arthrocnemetea fruticosi*) – 25,9 % pa enoletnim slanim pionirskim združbam, v katerih prevladuje navadni osočnik *Salicornia europaea*. Značilnih sredozemskih slanih močvirij (*Juncion maritimi*) je tu malo. Avtorja zaključujeta, da se je laguna Stjuža po delni opustitvi rabe razvila v pestre habitate obmorskih mokrišč.

Ključne besede: obalna laguna, vegetacija, habitatni tipi, PHYSIS, kartiranje, GIS

REFERENCES

- Avčín, A., I. Keržan, L. Kubik, N. Meith-Avčín, J. Štirn, P. Tušnik, T. Valentinčič, B. Vrišer & A. Vukovič (1974): Akvatični ekosistemi v Strunjanskem zalivu. I. Preliminarno poročilo. V: Prispevki k znanosti o morju, 1973, št. 5. Inštitut za biologijo univerze v Ljubljani, Morska biološka postaja, Piran, str. 168–216.
- Boteva, D., G. Griffiths & P. Dimopoulos (2004): Evaluation and mapping of the conservation significance of habitats using GIS: an example from Crete, Greece. *J. Nat. Conserv.*, 12, 237–250.
- Coreggi, G. (1873): *Regolazione dell'imposta fondiaria. (mscr.)*
- Čarni, A., M. Jarnjak & K. Oštir-Sedej (1998): Past and present forest vegetation in NE Slovenia derived from old maps. *Appl. Vegetation Sci.*, 1, 253–258.
- Darovec, D. (1992): Pregled zgodovine Istre. Zgodovinsko društvo za južno Primorsko, Koper, 88 str.
- Devillers, P. & J. Devillers-Terschuren (1996): A classification of Palearctic habitats. *Nature and Environment*. Council of Europe Publishing, 194 pp.
- Directive 92/43/EEC (1992): Council Directive of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.
- Firbas, P. (2001): Stjuža. V: Pogačnik, A. (ur.): Vsa slovenska jezera. Leksikon slovenskih stoječih voda. DZS, Ljubljana, str. 284–285.
- Forman, R. T. T. & M. Godron (1986): *Landscape ecology*. Toronto, Wiley, 619 pp.
- Green, D. R. & S. Hartley (2000): Integrating Photointerpretation and GIS for Vegetation Mapping: Some Issues and Error. In: Alexander, R. & A. C. Millington (eds.): *Vegetation Mapping*. Chichester, Wiley, p. 103–143.
- Jogan, N., M. Kaligarič, I. Leskovar Štamcar, A. Seliškar & J. Dobravec (2004): Habitatni tipi Slovenije: Tipologija. MOP-ARSO, Ljubljana, 64 str.
- Kaligarič, M. (1985): Botanični sprehod po Sečoveljskih solinah. *Proteus*, 48(3), 102–106.
- Kaligarič, M. (1996): Threat Status of Halophyte Flora and Vegetation. (Ogroženost halofitne flore in vegetacije.) V: Gregori, J., A. Martinčič, K. Tarman, O. Urbanc-Berčič, D. Tome & M. Zupančič (ur.): *Narava Slovenije, stanje in perspektive*. Društvo ekologov Slovenije, Ljubljana, str. 113–121.
- Kaligarič, M. (1999a): Diverziteta flore in vegetacije slanišč ob slovenski obali. V: Forte, J. & L. Lipej (ur.): *Biodiverziteta in varstvo slovenskega morja na pragu 21. stoletja*. Nacionalni inštitut za biologijo, Morska biološka postaja, Piran, str. 40–42.
- Kaligarič, M. (1999b): Novosti v poznavanju halofitne vegetacije na slovenski obali. V: Jogan, N. (ur.): *Zbornik izvodkov referatov simpozija Flora in vegetacija Slovenije 1999*. Botanično društvo Slovenije, Ljubljana, str. 16.
- Kati, V., P. Devillers, M. Dufrene, A. Legakis, D. Vokou & P. Lebrun (2004): Hotspots, complementary of representativeness? Designing optimal small-scale reserves for biodiversity conservation. *Biol. Conserv.*, 120, 471–480.
- Kos, V. (1996): *Atlas Slovenije*. Mladinska knjiga, Ljubljana, 440 str.
- Marchesetti, C. (1896–97): *Flora di Trieste e de'suoi dintorni*. Atti Mus. Civ. Stor. Nat. Trieste.
- Pienkowski, M. W., E. M. Bignail, C. A. Galbraith, D. I. McCracken, R. A. Stillman, M. G. Boobyer & D. J. Curtis (1996): A simplified classification of land-type zones to assist the integration of biodiversity objectives in land-use policies. *Biol. Conserv.*, 75, 11–25.
- Poldini, L., M. Vidali & M. L. Fabiani (1999): La vegetazione del litorale sedimentario del Friuli-Venezia Giulia (NE Italia) con riferimenti alla regione Alto-Adriatica. *Stud. Geobot.*, 17, 3–68.
- Pospichal, E. (1897–1898): *Flora des Oesterreichischen Kustenlandes*. Leipzig u. Wien, 2(1).
- Radinja, D. (1979): Mladinski raziskovalni tabori 1973–1974. Republiški koordinacijski odbor gibanja "Znanost mladini", Ljubljana, str. 55–68.
- Rajšp, V. & M. Ficko (1996): Slovenija na vojaškem zemljevidu (Josephinische Landesaufnahme 1763–1787 fuer das Gebiet der Republik Slowenien). ZRC SAZU and Arhiv Republike Slovenije.
- Salman, A. H. P. M. (1994): ECONET and coastal areas and wetlands: the golden fringe of Europe. In: Bennett, G. (ed.): *Conserving Europe's Natural Heritage. Towards a European Ecological Network*. Proceed. Int. Conf., 9–12 November 1993, Maastricht, Netherlands. Kluwer, London, p. 113–124.
- Smith, P. G. R. & J. B. Theberge (1986): A review of criteria for evaluating natural areas. *Environ. Manage.*, 10, 715–734.
- Stoms, D. M., M. J. Bueno, F. W. Davis, K. M. Cassidy, K. L. Driese & J. S. Kagan (1998): Map-guided classification of regional land cover with multi-temporal AVHRR data. *Photogramm. Eng. Rem. S.*, 64, 831–838.
- Wraber, T. (1974): *Gradivo za floro Strunjana*. Mednarodni mladinski tabori 1971–1972, str. 139–161.

App. 1: Complete list of habitat types, including names, PHYSIS and FFH codes and syntaxonomic units (where appropriate).

App. 1: Popoln seznam habitatnih tipov, ki vključuje njihova imena, kode PHYSIS in FFH ter sintaksonomske enote, kjer obstajajo.

PHYSIS Habitat code	Name of the habitat	Syntaxonomic unit	Aggregate code used in Fig. 2	FFH Code
11.33	Mediterraneo – Pontic <i>Cymodocea</i> and <i>Zostera</i> beds Mediterranean beds of <i>Cymodocea nodosa</i> , <i>Zostera noltii</i> and <i>Zostera marina</i> .	<i>Cymodoceion nodosae</i> Den Hartog 1976, <i>Zosterion</i> Christiansen 1934	1	
11.33x21	Intermediate type		1	
11.412	Brackish waterbodies with <i>Ruppia cirrhosa</i> Stands of <i>Ruppia cirrhosa</i> , colonising brackish waterbodies, shoals, abandoned salt-pans and river mouths.	<i>Ruppion maritimae</i> Br.-Bl. 1931	1	
13.11	Brackish rivers Brackish lower stream of rivers caused by tide.		2	
13.2	River mouths, estuaries Usually broad river mouths, deltas into the sea. Detailed habitats can be specified by means of the subdivisions of 11.		2	1130
14	Sand or mud banks without vascular vegetation beds Sand or mud sea banks, usually without vascular plants, can be overgrown by algae or cyanobacteria. Similar permanently flooded habitats belong to subdivisions of 21.		2	1140
14x15.113	Intermediate type		2	1140x1310
15.113	Mediterranean glasswort swards Annual salt pioneer swards, in particular <i>Salicornia herbacea</i> , colonising periodically inundated muds of Mediterranean coastal saltmarshes.	<i>Salicornion patulae</i> Gehu et Gehu-Franck 1984	3	1310
15.113x15.61	Intermediate type		3	1310x1420
15.113x53.6	Intermediate type		3	1310
15.113x87.2	Intermediate type		3	1310
15.11xTamarisk stands	Intermediate type		3	1310
15.51	Mediterranean tall rush saltmarshes – <i>Juncion maritimi</i> Beds of <i>Juncus maritimus</i> or <i>J. acutus</i> of periodically inundated depressions of the Mediterranean. In Slovenia, only <i>J. maritimus</i> is known to occur.	<i>Juncion maritimi</i> Br.-Bl. 1931 (<i>Juncetum maritime-acuti</i> Horvatić 1934)	4	1410
15.51x53.6	Intermediate type		4	1410

15.61	Mediterranean saltmarsh scrubs Low shrubby expanses of woody glass-worts, seabites, sea purslanes or <i>Halocnemum</i> , characteristic of inundated saltmarshes of the Mediterranean coasts. Characterised by dominant species belonging to <i>Arthrocnemum</i> , <i>Halimione</i> and <i>Limonium</i> genus.	<i>Arthrocnemion fruticosi</i> Br.-Bl.1931 corr. O. Bolos 1967	5	1420
15.61x53.6	Intermediate type		5	1420
15.61x87.2	Intermediate type		5	1420
17.2	Rocky shore communities of annuals Rocky shores with several plants like <i>Atriplex</i> spp., <i>Salsola soda</i> , <i>Cakile maritime</i> ...	<i>Cakiletea maritima</i> Tüxen et Preising, Tüxen 1950	5	1210
21	Coastal lagoons Saline or hypersaline waters cut off from the sea completely or still connected to the sea by narrow passages. The presence of marine invertebrate communities or vegetation can be indicated by addition of other habitat codes.		6	1150
31.8122	Sub-Mediterranean blackthorn-privet scrub Thermophilous shrub communities of the Sub-Mediterranean part of Slovenia, occupying a large range of the mentioned area. Occurring in hedges dividing karst grasslands (Istria, flysch area), forest edges, woodland recolonisation communities or on sites exposed to sun. On steep rocky edges it can occur as a pioneer forest. Formed by <i>Prunus mahaleb</i> , <i>Frangula rupestris</i> , <i>Cotinus coggygria</i> , <i>Fraxinus ornus</i> , <i>Rubus ulmifolius</i> , <i>Ligustrum vulgare</i> , <i>Carpinus orientalis</i> , <i>Cornus mas</i> , <i>Berberis vulgaris</i> .	<i>Ligustro-Prunetum</i> Tx. 1952	7	
31.8122x53.6	Intermediate type		7	
31.8122x87.2	Intermediate type		7	
53.6	Reed beds Communities of the margins of lakes, sea inlets, rivers and brooks, eutrophic marshes, swamps, ditches dominated by tall Poaceae- like <i>Phragmites</i> .	<i>Phragmitetum communis</i> Koch 1926 subass. <i>halophyllum</i> Pignatti 1953	8	
53.62	Giant reed stands Secondary formations of <i>Arundo donax</i> .		10	
53.62xTamarisk stands	Intermediate type		9	
53.6x53.62	Intermediate type		9	
53.6x87.2	Intermediate type		9	
83.11	Olive groves Mediterranean intensively farmed and traditional plantations of <i>Olea europaea</i> .		10	

83.151	Extensively farmed high-stem fruit orchards High-stem orchard of apple, pear, cherry, often extensively farmed. Low density of trees allows mowing of herb undergrowth.		10	
83.152	Intensively farmed high-stem fruit orchards High-stem orchard in Sub-Mediterranean, often intensively farmed. High density of trees planted in rows.		10	
83.152x85.31	Intermediate type		10	
83.3	Plantations Cultivated ligneous formations planted most often for the production of wood, composed of exotic species or native species out of their natural range and habitat.		7	
83.3x87.2	Intermediate type		7	
83.324	Locust tree plantation Plantations and spontaneous formations of <i>Robinia pseudacacia</i> .		7	
83.324xTamarisk stands	Intermediate type		7	
84.2	Hedgerows Small tree and shrub formations arranged in a linear or reticulated manner, closely with grassy or cultivated habitats, usually serving as partitions and shelter.		7	
85.11	Park woodlots Copses, groves of woods of native or introduced trees, with or without accompanying shrubbery and herbaceous undergrowth, constituting elements of urban parks.		7	
85.12	Park lawns Frequently mown grassland (more than 3 times per year), composed of native or sometimes exotic grasses, constituting elements of urban parks.		11	
85.12x87.2	Intermediate type		11	
85.31	Ornamental gardens Areas of land adjoining a house, planted with ornamental grass, shrubs, trees, flower beds.		11	
86.2	Villages Small groups of houses in rural areas, susceptible to strong interconnection between usages by the fauna of the built-up and countryside habitats. Includes bordering areas of town suburbs and isolated buildings.		12	

87.2	Ruderal communities Communities of pioneering, introduced or nitrophilous plants colonising waste places, disturbed natural or seminatural areas, roadsides and other interstitial spaces or disturbed ground.	<i>Sysimbrion officinalis</i> Tx- et al., Tx. 1950, <i>Dauco-Melilotion</i> Goers 1966, <i>Artem- isio-Egropyron inter- medii</i> Mueller et Go- ers 1969.	9	
87.2xTamarisk stands	Intermediate type		9	
89.11	Sea harbours Seaside complexes of artificial basins and inlets constructed for the purposes of navigation.		12	
89.12	Salt-pans Active or recently abandoned salt-extraction basins. When vegetation is established, detailed habitats can be specified by means of the subdivisions of 15.		13	
89.22	Ditches and small canals Narrow linear artificial freshwater bodies, mostly used for irrigation or as partitions, in this case for the purpose of salt-extraction basins.		14	
-	Tamarisk stands		9	
-	Asphalted road		15	
-	Macadamised road		15	
-	Path		15	

original scientific article
received: 2005-

UDC 631.1:630*22(497.4)

RELATIONS BETWEEN LAND-USE AND SOCIO-ECONOMIC STRUCTURE ON FARMS WITH AND WITHOUT AGRICULTURAL LAND ABANDONMENT

Andreja BOREC & Karmen PAŽEK

Faculty of Agriculture, University of Maribor, SI-2000, Vrbanska 30

E-mail: andreja.borec@uni-mb.si

Antonin FLAMBARD

École Nationale Supérieure Agronomique de Rennes (ENSAR), CS 84215N - 35042 Rennes Cedex, 65 rue de Saint Briec, France

ABSTRACT

Agricultural land abandonment and forest expansion is becoming a serious problem in Slovenia. Spontaneous forest expansion has a negative effect on natural and social conditions. Thus the consideration of natural and social conditions is of high importance when taking measures to prevent forest expansion. In the article, the comparison of farms with and without abandonment of agricultural use regarding land-use and socio-economic characteristics was made. The results of χ^2 test show no statistically significant differences at the level of $p < 0.05$ between farms with and those without abandonment of agricultural land regarding socio-economic structure. Analysis of variance ANOVA was used for estimating the difference between various socio-economic structures on farms with abandoned agricultural land. The results of ANOVA show a statistically significant difference ($p > 0.05$) between socio-economic structures on the farms with abandonment of agricultural land. The ANOVA results pointed out that aged farms have the largest abandoned land areas. In order to ascertain the differences between farms with and those without abandoned agricultural land regarding their land use structure, t-test was carried out, and its results have shown no statistically significant differences between farms with and those without abandoned agricultural land regarding land-use structure.

Key words: land-use, socio-economic structure, abandonment of agricultural land

COMPARAZIONE TRA FATTORIE CON O SENZA SUPERFICI AGRICOLE ABBANDONATE RELATIVAMENTE ALL'USO DEL SUOLO E ALLE CARATTERISTICHE SOCIO – ECONOMICHE

SINTESI

L'abbandono dei terreni agricoli ed il loro rinselvaticamento è in Slovenia un problema serio che si riflette negativamente sia sull'ambiente sia sulla società in generale. Le peculiarità naturali e la situazione sociale assumono perciò grande importanza nel proporre misure atte ad arrestare il fenomeno. Il presente contributo fa un confronto tra fattorie con o senza superfici agricole abbandonate relativamente all'uso del suolo e al tipo socio – economico di fattoria. I risultati χ^2 ottenuti nel test con $p < 0,05$ non mostrano differenze rilevanti nella struttura socio – economica delle fattorie con terreni coltivabili abbandonati o prive di essi. L'analisi della varianza ANOVA (con $p > 0,05$) rivela una differenza statistica notevole nella struttura socio – economica delle fattorie con terreni agricoli abbandonati. I risultati di quest'ultima analisi confermano l'ipotesi che le superfici agricole abbandonate più grandi appartengono alle fattorie più antiche. Per scoprire le differenze tra le fattorie con o senza terreni coltivabili abbandonati relativamente all'uso del suolo si è ricorsi al t-test, i cui risultati non rivelano differenze statisticamente rilevanti.

Parole chiave: uso del suolo, tipo socio – economico di fattoria, abbandono delle superfici agricole

INTRODUCTION

Slovenia is one of those European countries with the smallest share of total and cultivated agricultural land. Only 33% of its surface area is covered by agricultural land and more than 59% is covered by forest (Official Gazette, 116/2004).

In Slovenia, forest expansion in the last 47 years has increased by 16%, and according to official data the forested area is still increasing (Krajnc, 2003). According to the stated data, abandonment of agricultural land and spontaneous forest expansion is a serious problem in Slovenia (<http://ats.agr.gc.ca/europe/e3222.pdf>, news link, 2004). According to Cunder (1998), the agricultural land is being abandoned in the entire country, particularly in the Alpine region. With the abandonment of agricultural land and spontaneous forest expansion are in fact faced many EU countries, although the reasons for such state of affairs in separate countries are not the same (Priska, 1995; Peterson & Aunap, 1998; Talvik, 2002; Krajnc, 2003; <http://www.humangeo.su.se/eng/publications/abstracts/2003-54.htm>, news link, 2004).

Regarding the research based on the 1991 census data, Perpar (2002) pinpointed the most important reasons for the abandonment of farm activities in Slovenia: young farmers do not see the future in farming, income from agriculture is too low, farms are small and agricultural land is too widely spread, the natural conditions for agricultural production are poor, and there is deficiency in farm successors as well as generally low reputation of farming. At the same time, giving up the agricultural cultivation has a negative effect on bio-physical and socio-economic structure of farms (Perpar, 2002).

Cunder (1998) and Golob (1994) stated that unfavourable natural conditions for agriculture, inconvenient socio-economic characteristics of farms and political circumstances of the past are the main reasons for agricultural land abandonment in Slovenia.

Different authors define many negative outcomes of agricultural land abandonment and spontaneous forest expansion: less cultivated agricultural land, abandonment of cultural landscapes (Perpar, 2002), changes in panoramic landscapes, game animals moving to valleys and to the cultivated landscape, low quality of young forests and lesser economic interest in them (<http://www.radiokobarid.si/news/>; news link, 2004), and a serious loss of biodiversity (<http://www.ieep.org.uk/reportsandpubs/Ruralareasnav.htm>; news link, 2004).

Regarding CORINE land cover map (<http://www.gu.gov.si/gu/predstav/predstav-p.asp>), the forest expansion in Slovenia can be found largely in the Less Favoured Areas (hereinafter referred to as LFA) (Official Gazette, 116/2004). Regarding the land-use, abandoned areas are mostly spread on pastures and grasslands

(SAZU – Slovene Academy of Sciences and Arts, 1989).

Irrespective of the fact that forest activities predominate in LFA, agriculture production in them still has an important role for the preservation of the sustained presence of population in rural areas and for maintaining cultural landscape (Ministry of Agriculture, Forestry and Food, 2004; Ministry of the Environment and Spatial Planning, 1997; Juvančič, 1996; Borec, 2003; Flambard, 2004).

In the article, the socio-economic farm structure as criteria for social conditions that could cause agricultural land abandonment was assessed. The socio-economic typology of farms structure is based on economic efficiency and reproductive ability of farms (Kovačič, 1996; Kerbler, 2003). Kovačič (1996) concluded that there are many important differences regarding socio-economic types of farms: the size of annual work unit (AWU), the age structure, the expanse of the families and the farm size.

As far as natural conditions are concerned, the land-use structure of farms is dealt with. Regarding land-use, some research work on the correlation between land abandonment and agricultural land use pointed out that there was a positive correlation particularly between forest and pastures (Čas, 1990; Mrakič, 2001). Lately, different projects have been proposed in Slovenia against agricultural land abandonment (Kompan *et al.*, 1997; Šalehar *et al.*, 2004), but quantitative results are still missing.

When dealing with forest expansion and abandonment, the areas that are still in the process of affecting the forest ecosystem must also be taken into account. Such areas are described as areas being abandoned and where all agricultural activities have already been stopped (Official Gazette, 30/1993). Simončič *et al.* (1999) considered such areas as areas where the abandonment process began 20 or fewer years ago.

The article analyses the differences between farms with and those without abandoned agricultural land regarding land use and socio-economic farm structure is made. The variables used for the statistical analysis were selected from similar research activities (Čas, 1990; Kovačič, 1996; Mrakič, 2001; Kerbler, 2003).

The final objective of the carried out research is to establish the most suitable farm profile in the struggle against the abandonment of agricultural land.

MATERIAL AND METHODS

Studied region

The farms in the mountainous region of northeast Slovenia were studied (Fig. 1) (Official Gazette, 18/2003).

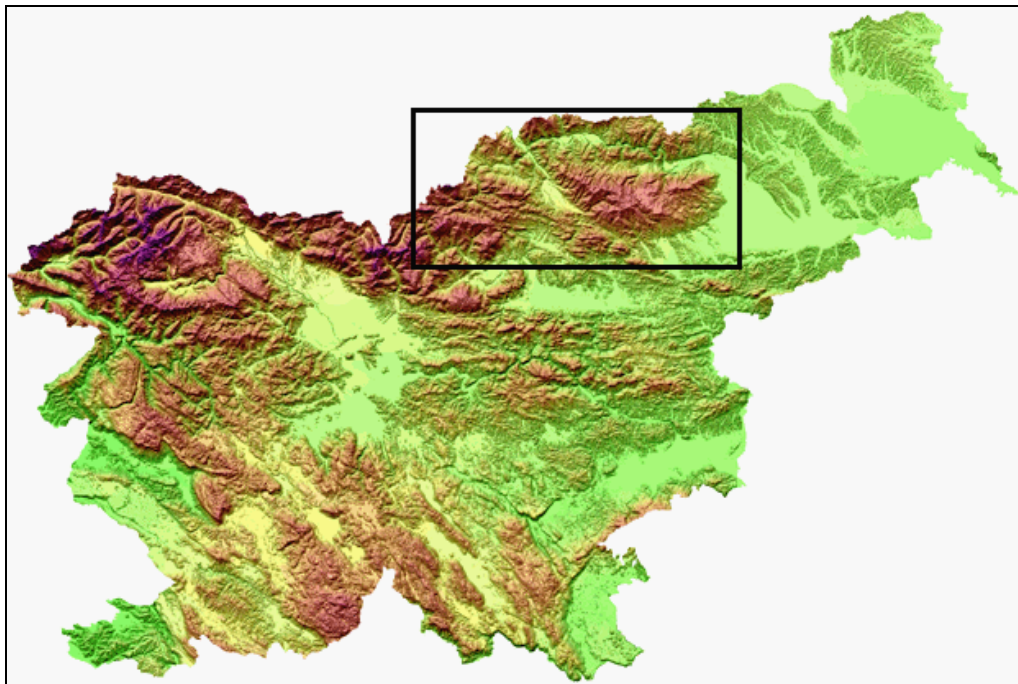


Fig. 1: Location of the studied region (scale: 1 cm = 15 km) (Source / Vir: [Sl. 1: Lokacija obravnavanega območja \(skala: 1cm = 15 km\).**](http://gis.zrc-sazu.si/zrcgis/?(164.8.66.95)).</p>
</div>
<div data-bbox=)**



Fig. 2: Upland areas in the studied region (scale: 1cm ≈ 7 km).

Sl. 2: Visokogorsko območje v obravnavani regiji (skala: 1 cm ≈ 7 km).

All municipalities of the studied region are classified as municipalities in LFA (EC Regulation 1257/99). In figure 2, the mountainous areas in the studied region are coloured green, whereas the municipalities' boundaries are in red.

The studied area encloses 22 municipalities. There have been some projects carried out only for single municipalities, and as only a couple of studies have been

made at the regional level, a wide range of current data regarding the studied area is missing.

Sample of farms

According to the limitations mentioned in 2.1 and according to the TTN 1:5000 (Basic Topographic Map), 1410 farms are located in the studied area. The selection

of farms was random, with the representative sample comprising 140 farms in the studied area.

Questionnaire

The questionnaire is divided into six parts: basic data about the farm, land-use and abandonment of agricultural land, livestock production, plant production and investments in farms. Each part has a different number of questions. Questions are of open and closed type. For the analysis, the questions related to the basic data of the farm, questions about land-use and abandonment of agricultural land and questions regarding livestock production were applied. For the sake of questionnaire validity, the questions were checked and analysed in accordance to many similar questionnaires, methodological explications and research activities (Kovačič, 1996; Brancelj, 1999; Kerbler, 2003; Krajnc, 2003; Glauben *et al.*, 2004; popisni list: http://www.agroport.si/download/pl_1-3.doc).

Procedure

The questionnaires were carried out in June and July 2004. The filling-in lasted approximately two hours for each farm. Farmers were well acquainted with the filling in of the questionnaire. No questionnaires were eliminated owing to incorrect filling. The questionnaires were performed by well-qualified questioners. The questions were answered by farm owners or their near relatives.

Analysis

On the basis of questionnaires, two farm clusters

were defined: farms with and those without abandoned agricultural land. In order to establish the differences between the two farm clusters according to their land-use and socio-economic structure, first the basic descriptive statistics were carried out. In order to understand the differences between farms with and those without abandoned agricultural land regarding their socio-economic structure, the χ^2 test was used. In order to see the differences between farms with and those without abandoned agricultural land regarding their land-use, the t-test was carried out. Statistical significance was set at α level of 0.05. Analysis of variance ANOVA was used for estimating the difference between various socio-economic farm structures concerning the abandonment of agricultural land. The ANOVA was carried out only on farms with abandoned agricultural land. The results are represented in tables and graphs.

RESULTS AND DISCUSSION

Farms in the studied area are mostly large; on average they cover 9 ha of agricultural land and 31.5 ha including forest, while the Slovenian average in 2003 was 6.3 ha of agricultural land and 12.0 ha including forest (Statistical Office of the Republic of Slovenia, 2004). Of the 140 surveyed farms, 71 are faced with land abandonment, which is more than a half of them. In the farms with abandoned agricultural land, the average size of forest expansion is almost 2 ha. The figure 3 shows that forest replaces mostly grassland and pastures on the periphery of the farm estate.

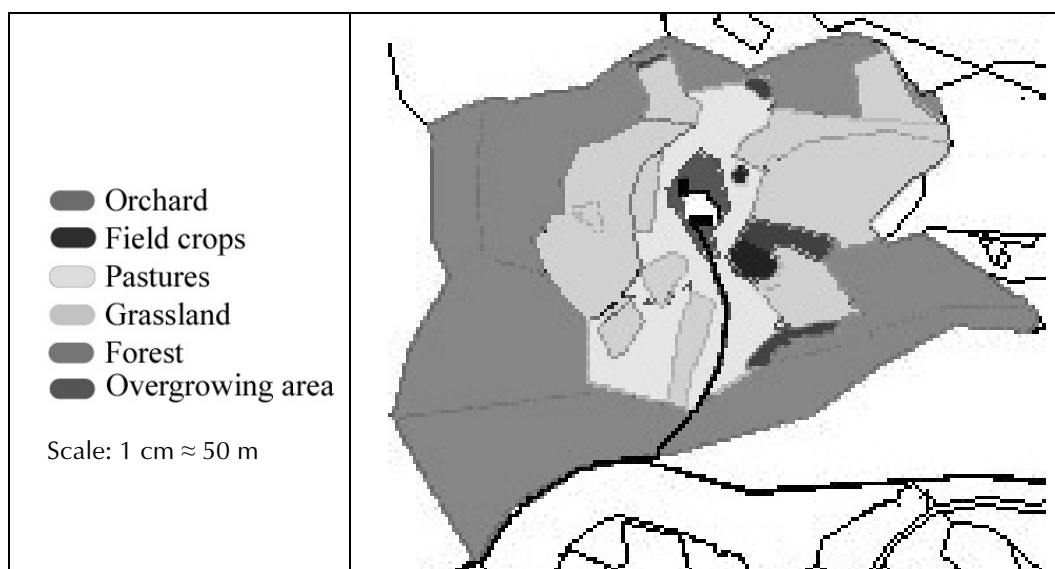


Fig. 3: Localisation of abandoned agricultural land on Grizolt farm.
Sl. 3: Opuščene kmetijske površine na kmetiji Grizolt.

Land-use analysis

For the land-use analysis, four variables were created. The selected variables are the main land-use structures in the studied area. Pastures and orchards are taken together, as the extensive orchards are, without exception, also used for grazing. The basic land-use analysis of farms indicated that farms with abandoned land are larger than farms without it, mainly due to forest and pastures with orchards areas (Fig. 4).

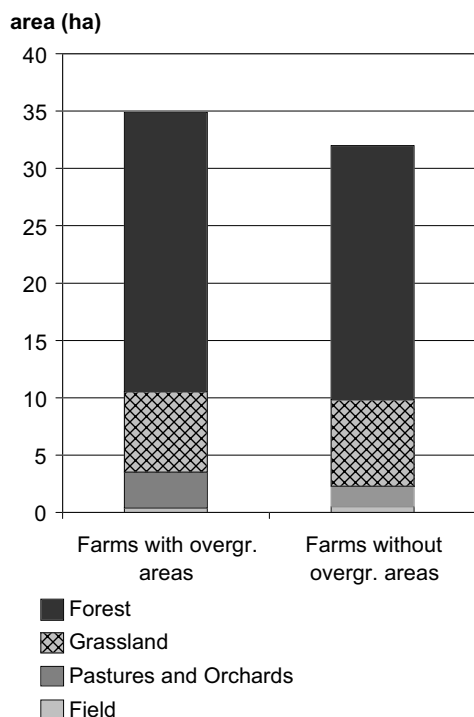


Fig. 4: Land-use structure of farms.

Sl. 4: Struktura rabe tal na obravnavanih kmetijah.

In order to establish statistical differences between farms with and those without abandoned agricultural land regarding their land-use structure, t-test was applied (Tab. 1).

The results in Table 1 show that standard deviations are very high, with the exception of grassland, which indicates a huge dispersion of results in the sample of farms. The average size of grassland area on farms with abandoned land is 6.96 ha, and 7.48 ha on farms without abandoned land. The difference between two farm clusters is not significant. The results of the next variable show that farms with abandoned land occupy, on average, 2.48 ha of pastures and orchards, and farms without such areas only 1.65 ha. The difference between two farm clusters regarding the areas of pastures and orchards is statistically significant ($p < 0.05$). By the variable Field, the average size of field area on farms with

abandoned land comes to 0.47 and on the farms without such areas to 0.53 ha. The difference between the two farm clusters regarding the size of field area is not significant either. The average size of forest on farms with abandoned land is 24.36 ha, and 22.29 ha on farms without abandoned land. The difference for forest is also not significant.

Tab. 1: T-test applied to assess the differences between farms with ($n = 71$) and those without ($n = 69$) abandoned agricultural land with regard to their land-use structure.

Tab. 1: Rezultati t-testa za kmetije z ($n = 71$) in brez ($n = 69$) opuščeni kmetijskih površin glede na strukturo rabe tal.

Land-use	Farms with abandoned land mean \pm SD (ha)	Farms without abandoned land mean \pm SD (ha)	p
Grassland	6.96 \pm 3.73	7.48 \pm 4.12	0.442
Pastures and orchards	2.48 \pm 2.45	1.65 \pm 2.18	0.037*
Field	0.47 \pm 0.69	0.53 \pm 0.56	0.583
Forest	24.36 \pm 17.98	22.29 \pm 28.26	0.607

* $p < 0.05$

The important role of livestock production should not be overlooked due to its role in land-use structure on farms (especially the size of pasture and grassland areas). The variables used for the basic analysis are gathered upon livestock food behaviour. Grazing livestock like cattle (suckling cows, milk cows, young cattle, calf, and bulls), goats and sheep are due to their importance against abandonment (Pogačnik *et al.*, 1995; Kompan *et al.*, 1997; Šalehar *et al.*, 2004; <http://www.ilbis.com/spark/st7cl5.htm>) treated independently, all granivores are dealt with as other livestock (poultry, pigs etc.). Figure 5 represents the livestock pressure on pastures (pastures and orchards). In 2003, the Slovenian average agricultural holding bred 6.9 livestock size units (LSU coefficient) per ha (Statistical Office of the Republic of Slovenia, 2004), whereas farms of the studied area bred 9.5 LSU per ha. Figure 5 shows that farms without abandoned land have doubled cattle pressure on pastures, which could partly explain why there is no spontaneous forest expansion. The pressure of small grazing livestock (goats and sheep) on pastures is also greater on farms without abandoned land than on farms with abandoned land. Farms with abandoned land have greater LSU coefficient only due to other livestock (granivores).

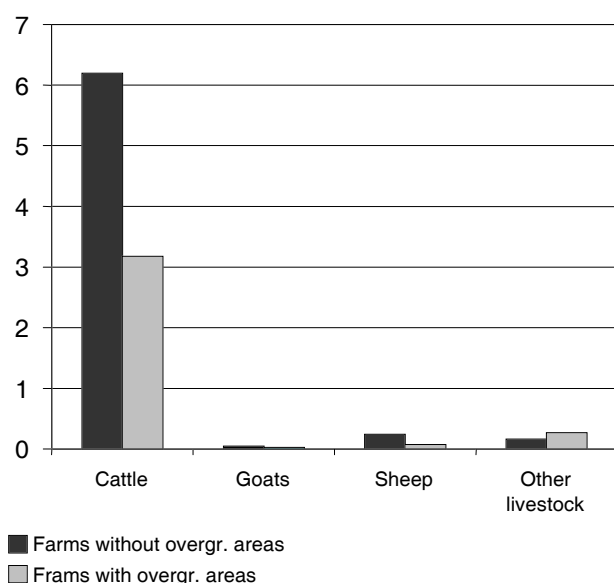


Fig. 5: Livestock pressure on pastures (LSU/ha).
Sl. 5: Obremenitev z živalmi na pašnikih (GVŽ/ha).

Regarding the production orientation on farms in the studied area, those with abandoned land have more diversified production (large number of various crops and livestock) than those without abandoned land (Tab. 2). Indeed, more than three quarters of farms with abandoned land (78.6%) practice a combined production of various crops and livestock. On the opposite, more than a half of farms without abandoned land are oriented only in grazing livestock production.

Tab. 2: Comparison of the farms' main production orientation (in %).

Tab. 2: Primerjava glede na proizvodno usmeritev kmetij (v %).

Farm cluster	Various crops and livestock production	Grazing livestock production	Field crops production	Total
Farms with abandoned land	78.6	21.4	0	100
Farms without abandoned land	40.7	55.6	3.7	100

The main conclusion after the analysis regarding land-use structure on farms with and without abandoned agricultural land is that farms without abandoned land are smaller, more focused on a single agricultural production, i.e. livestock production and greater grazing livestock pressure on pastures.

The results obtained from land-use analysis are expected to consider the previous research carried out into the importance of grazing livestock breeding against the

abandonment of agricultural land (Kompan *et al.*, 1997; <http://www.rtd.si/slo/6op/podr/trajraz/globeko/gradivo/>; <http://www.nordgen.org/english/publications/articles.htm>, link 2004).

Čepin *et al.* (1995) indicate that regarding the agricultural land-use structure in Slovenia (64.5% of grasslands), at least 230,000 cows or 580,000 cattle will be needed to prevent forest expansion on agricultural land and to preserve the settlements and landscape.

Analysis of socio-economic farm characteristics

The classification according to Kovačič (1996) was used to determine the socio-economic farm structure. In the studied area, the so-called living farms (agriculturally non-active farms, where all the family members live on the farm, but the agricultural land is leased) were also included in the analysis.

Tab. 3: χ^2 test for estimating the differences between farms with and those without abandoned agricultural land regarding socio-economic farm structure.

Tab. 3: Ocene χ^2 testa med kmetijami z in brez opuščenih kmetijskih površin glede na socio-ekonomski tip kmetije.

Socio-economic farm structure		Farms with abandoned land	Farms without abandoned land	Total
Full-time farm	f	24	35	57
	f (%)	40.7	59.3	100
Part-time farm	f	39	24	63
	f (%)	61.9	38.1	100
Living farm	f	2	2	4
	f (%)	50	50	100
Aged farm	f	3	5	8
	f (%)	37.5	62.5	100
Supplementary farm	f	3	3	6
	f (%)	50	50	100
Total	f	71	69	140
	f (%)	50.7	49.3	100
χ^2 outcome		$\chi^2 = 6.146, p = 0.189, V = 0.209$		

The results of χ^2 test show (Tab. 3) no significant differences at the level of $p < 0.05$ between farms with and those without abandoned agricultural land regarding socio-economic farms structure.

However, Table 3 indicates a high portion of part-time and full-time farms against living, aged and supplementary farms. Among full time farms, farms without abandoned land predominate with 59.3%, followed by farms with abandoned land (40.7%). Among part-time farms, more than half are faced with abandonment

(61.9%). Living and supplementary farms have equal distribution between farms with and those without abandoned land. Among aged farms with only 8 farms in the studied area, farms without abandoned land predominate (62.5%).

The analysis of farms with abandoned land shows (Tab. 4) that more than half of the farms (54.9%) are part-time farms. Among the farms without abandoned land, full-time farms predominate (50.7%).

Tab. 4: Analysis of socio-economic farm structure of farms with and those without abandoned agricultural land.

Tab. 4: Analiza socio-ekonomskih tipov na kmetijah z in brez opuščenih kmetijskih površin.

	Socio-economic farm structure (%)					
	Full-time	Part-time	Living	Aged	Sup pl.	Total
Farms with abandoned land	33.8	54.9	2.8	4.2	4.2	100
Farms without abandoned land	50.7	34.8	2.9	7.2	4.2	100

To further discuss the relations between socio-economic farm structures regarding abandoned land, the ANOVA was used (Tab. 5), for which only farms with abandoned agricultural land were taken into account.

Tab. 5: ANOVA for estimating the differences between socio-economic farm structures regarding abandoned agricultural land only on farms with abandoned areas.

Tab. 5: ANOVA za oceno razlik med socio-ekonomskimi tipi kmetij glede na površino opuščenih kmetijskih zemljišč samo za kmetije z opuščenimi površinami.

Socio-economic farm structure	N	mean \pm SD	F	p
Full-time farm	24	1.74 \pm 1.49	4.508	0.003
Part-time farm	39	1.45 \pm 2.29		
Living farm	2	1.75 \pm 0.35		
Aged farm	3	6.90 \pm 5.37		
Supplementary farm	3	2.60 \pm 0.54		
Total	71	1.84 \pm 2.37		

The results of ANOVA show a significant difference ($p < 0.05$) between different socio-economic farm structures concerning the abandonment of agricultural land. Post hoc analysis revealed significant differences between full-time and aged farms and part-time and aged farms. The mean values show that aged farms have most abandoned land (6.9 ha). In Table 5, high values of SD are also recognized, which indicates a high dispersion of results.

Aged farms have the highest portion of abandoned

land probably due to the lack of labour. The reasons for more abandoned land at supplementary farms are most likely associated with predominance of non-agricultural activities on these farms. The expenses of abandoned land at full-time, part-time and living farms are almost the same; however, the SD at all tree farm types differs substantially.

The results concerning the farm profile with abandoned agricultural land could be explained as follows: compared to farms without abandoned land, those with such land are more expansive, with larger forest and pasture areas and with lower livestock pressure on pastures. Comparing the socio-economic farm structure of both farm clusters with farms with abandoned land, part-time farms and farms with various crops and livestock combined production orientation predominate. The biggest portion of abandoned land is also associated with aged farms. The profile of farm without abandoned land could be explained by the fact that such farms are smaller compared to farms with abandoned land, with double livestock pressure on pastures. At farms without abandoned land, full-time farms predominated, with farm production focusing on grazing livestock.

CONCLUSIONS

In the mountainous areas of northeastern Slovenia, natural conditions are not suitable for agriculture mainly owing to the rough relief of the territory and its unfavourable climate. For the last hundred years, this region has faced problems of depopulation and consequently a falling number of livestock and the abandonment of agricultural land. As a result, the spontaneous forest expansion has continuously progressed on farmlands.

Based on a sample of 140 farms, first the distribution of farms in two clusters was made: farms with and farms without any abandoned agricultural land. For the comparison between the two farm clusters, different variables were selected with regard to land-use and socio-economic characteristics.

The analysis of land-use structure on farms shows that farms with abandoned land are larger especially due to forest and pastures. In order to compare the farms with and those without abandoned land regarding land-use, t-test was applied. The results showed no statistically significant differences between farms with and those without abandoned land regarding land-use.

By supposing that grazing livestock production is of great importance for the size and diversity of land-use (Pogačnik, *et al.*, 1995; Kompan *et al.*, 1997; Šalehar *et al.*, 2004; <http://www.ilbis.com/spark/st7cl5.htm>), additional analyses were carried out. They indicate that farms without abandoned land have fewer pastures, but more than double grazing livestock pressure on it (counting in LSU). Irrespective of the fact that production of various crops and livestock predominates on farms,

the farms without abandoned land are much more focused only on grazing livestock production (especially cattle breeding).

The analysis of the differences between farms with and those without abandoned land regarding the socio-economic farm structure was carried out with basic statistical analysis, χ^2 test and ANOVA.

The basic conclusion is that part-time farms predominate before full-time farms in the studied area (amounting together to 85.7%). The remaining three farm structures jointly occupy only 14.3% of total farms in the studied area. Among part-time farms, those with abandoned land predominate (61.9%), while among full-time farms those without abandoned land are predominant (59.3%). Irrespective of the noticeable differences among some farm structures regarding land abandonment, no statistical differences with χ^2 test ($p > 0.05$) could be stated. The additional analysis pointed out that

among farms with abandoned land, part-time farms are predominating (54.9%), and full-time farms (50.7%) among farms without abandoned land. To estimate the differences between socio-economic farm structure regarding size (ha) of abandoned agricultural land, the ANOVA was used, for which only farms with abandoned land were taken into account. The results indicate a statistical significance at the $p < 0.05$ level, which is in a way not surprising at all. On aged farms, which are faced with the largest share of abandoned land, lack of labour was also established.

The results of all the carried out analyses are expected and understandable. In order to better understand both farm clusters, several research activities, especially concerning natural conditions, must be carried out. Last but not least, the richness and complexity of handling data would enhance a global perspective on the abandonment problem.

PRIMERJAVA KMETIJ Z OPUŠČENIMI KMETIJSKIMI POVRŠINAMI IN BREZ NJIH GLEDE NA RABO TAL IN SOCIO-EKONOMSKE ZNAČILNOSTI

Andreja BOREC & Karmen PAŽEK

Fakulteta za kmetijstvo, Univerza v Mariboru, SI-2000, Vrbanska 30

E-mail: andreja.borec@uni-mb.si

Antonin FLAMBARD

École Nationale Supérieure Agronomique de Rennes (ENSAR),

CS 84215N - 35042 Rennes Cedex, 65 rue de Saint Briec, France

POVZETEK

V Sloveniji je opuščanje kmetijskih površin in zaraščanje z gozdom resen problem, saj oba procesa negativno vplivata tako na okolje kot na družbo nasploh. Naravnim danostim in družbenim razmeram se zato pri načrtovanju predlogov za zmanjševanje oziroma zaustavitev procesa opuščanja in sprotne zaraščanja kmetijskih površin pripisuje velik pomen. Prispevek obravnava primerjavo kmetij z opuščeni kmetijskimi površinami in brez njih glede na rabo tal in socio-ekonomski tip kmetij. Pri $p < 0,05$ rezultati χ^2 testa ne kažejo statistično značilnih razlik v socio-ekonomski strukturi kmetij pri kmetijah z opuščeni kmetijskimi površinami in brez njih. Rezultati analize variance ANOVA kažejo na statistično značilno razliko (pri $p > 0,05$) v socio-ekonomski strukturi kmetij z opuščeni kmetijskimi površinami. Rezultati analize variance potrjujejo predvidevanje, da so večje kmetijske površine opuščene na starih kmetijah. Za ugotavljanje razlik med kmetijami z opuščeni kmetijskimi površinami in brez njih glede na strukturo rabe tal je bil uporabljen t-test, katerega rezultati ne kažejo statistično pomembnih razlik.

Ključne besede: raba tal, socio-ekonomski tip kmetij, opuščanje kmetijskih površin

REFERENCES

- Borec, A. (2003):** Okoljski indikatorji in trajnostni razvoj kmetijskega prostora. Univerza v Mariboru, Fakulteta za kmetijstvo, Maribor, 1–16.
- Brancelj, I. (1999):** Environmental protection aspects of agriculture in landscape region of Slovenia. *Geografski zbornik*, 39, 93–132.
- Cunder, T. (1998):** Kmetijstvo in ohranjanje poseljenosti v Sloveniji. Kmetijstvo in okolje. Zbornik posveta, Ljubljana, str. 37–47.
- Čas, M. (1990):** Naturnahes Waldland Slowenien. ÖFZ: Können sie ein mehnendes Beispiel aus unseren geographischen Breiten nennen?. *Österreichische Forstzeitung*, No. 9, p. 23.
- Čepin, S., J. Ferčej & M. Čepin, (1995):** Milk Production in Slovenia. Book of Abstracts. 1st Slovenian International Congress "Milk and Dairy Products" and 10th International Symposium of the Institute for Dairying "Modern Milk Production and Processing". 20–22 September 1995, Portorož, Slovenija. Biotechnical Faculty, Domžale, p. 87.
- EC Regulation 1257/99:** The Rural Development Regulation.
- Flambard, A. (2004):** Situation of the mountain farms facing overgrowing in North-east Slovenia. ENSAR 151 – Génie de l'Environnement. Option système de Production et de Développement Rural. Bachelor Degree. University of Maribor, Faculty of Agriculture, Maribor, 91 pp.
- Golob, A. (1994):** Raba zemljišč v zaraščanju v Sloveniji. Kako izboljšati posestno strukturo v Sloveniji / IX. tradicionalni posvet kmetijske svetovalne službe, Bled, 21. in 22. november 1994. – Ljubljana : Republiška uprava za pospeševanje kmetijstva, 89–98.
- Glauben, T., H. Tietje & S. Vogel. (2004):** Farm succession patterns in Northern Germany and Austria. Institut für nachhaltige Wirtschaftsentwicklung, Wien, p. 1–11. <http://www.rtd.si/slo/6op/podr/trajraz/globeko/gradivo/>
- <http://www.nordgen.org/english/publications/articles.htm>
- <http://www.gu.gov.si/gu/predstav/predstav-p.asp>
- http://www.radiokobarid.si/news/news_archive_show.php?file=arhiv/n_01302.txt
- <http://www.ilbis.com/spark/st7cl5.htm>
- <http://www.humangeo.su.se/eng/publications/abstracts/2003-54.htm>
- http://www.agroport.si/download/pl_1-3.doc
- http://www.ieep.org.uk/PDFfiles/PUBLICATIONS/RuralAreasNewslink/Newslink8_GB.pdf
- [http://gis.zrc-sazu.si/zrcgis/\(164.8.66.95\)](http://gis.zrc-sazu.si/zrcgis/(164.8.66.95))
- <http://ats.agr.gc.ca/europe/e3222.pdf>
- <http://www.stat.si/doc/statinf/2004/si-96.pdf>
- Juvančič, L. (1996):** Regionalna politika Evropske unije in Slovenije – primerjalna in empirična analiza kazalcev gospodarske razvitosti podeželskih območij. Diplomski naloga. Univerza v Ljubljani, Biotehniška fakulteta, Ljubljana, 98 str.
- Kerbler, B. (2003):** Aplikativna razvojna tipologija hribovskih kmetijskih gospodarstev v občini Ribnica na Pohorju. *Geografski vestnik*, 75(1), 103–116.
- Kompan, D., M. Pogačnik, T. Vidrih, P. Juntos, M. Kotar, F. Habe (1997):** Small ruminants and sustainable agriculture – our experience. In: Kukovisc, S. (ed.): Sheep and goat husbandry in the Central and Eastern European Countries – a struggle to survive : international workshop. 29th November – 3rd December, 1997, Budapest. Ministry of Agriculture, National Committee for Technological Development, p. 67.
- Kovačič, M. (1996):** Socio-ekonomska in velikostna struktura kmetij v Sloveniji v obdobju 1981–1991. Univerza v Ljubljani, Biotehniška fakulteta, Ljubljana, str. 31–37.
- Krajnc, N. (2003):** Forests and use of biomass in Slovenia. *Wood energy*, 2, 29–32.
- Ministry of agriculture, Forestry and Food, (2004):** Rural development plan for the Republic of Slovenia 2004–2006. Ministry of Agriculture, forestry and Food, Ljubljana.
- Ministry of the Environment and Spatial Planning, (1997):** Slovene Agriculture, Forestry and Food Industry in Figures. Ljubljana, p. 17–25.
- Mrkič, J. (2001):** Analyses of changes of cultural landscape: case study of Sv. Anton na Pohorju cadastral community. Master Thesis. Polytechnic, Nova Gorica, 94 pp.
- Official Gazette (1993):** Zakon o gozdovih. U. I. RS, št. 30/1993.
- Official Gazette (2003):** Uredba o kriterijih za določitev območij z omenjenimi možnostmi za kmetijsko dejavnost. U. I. RS, št. 18/2003.
- Official Gazette (2004):** Program razvoja podeželja za Republiko Slovenijo 2004–2006. U. I. RS, št. 116/2004.
- Pogačnik, M., D. Kompan, T. Vidrih, M. Kotar & B. Matičič (1995):** Recultivation of abandoned hilly karst grassland by sheep and goats. *Sodobno kmetijstvo*, 5, 225–229.
- Perpar, A. (2002):** Stanje in procesi v kmetijstvu v različnih tipih podeželskih območij v Sloveniji. Zbornik Biotehniške fakultete, Ljubljana, 97(1), 281–300.
- Peterson, U. & R. Aunap (1998):** Changes in agricultural land use in Estonia in the 1990s detected with multitemporal Landsat MSS imagery. *Landscape and Urban Planning*, 41(3–4), 193–201.
- Priska, B. (1995):** Forest expansion in the Swiss Alps: a quantitative analysis of bio-physical and socio-economic causes with an emphasis on structural change in agriculture. Proposal form. National Research Programme NRP 48 "Landscapes and Habitats of the Alps.
- SAZU – Slovene Academy of Sciences and Arts (1989):** Svet za proučevanje in varstvo okolja. Slovenija 88: zbornik Okolje in razvoj. Ljubljana, 381 str.

Simončič, P., A. Kobler, R. Robek & L. Žgajnar (1999): Ocena emisij oz. ponora TGP za gozdarstvo ter spremembe rabe zemljišč. Gozdarski inštitut Slovenije., Ljubljana, str. 1–27.

Statistical office of the Republic of Slovenia, (2004): Farm structure Survey, 1 June 2003. Rapid reports. Statistical office of the Republic of Slovenia. Ljubljana, 96, p. 1–19 (<http://www.stat.si/doc/statinf/2004/si-96.pdf>).

Šalehar, A., S. Kavčič, M. Čepon, D. Kompan, D. Tomažič & M. Žan (2004): Pomen živalskih genskih virov in nacionalne prednostne naloge pri ohranjanju ter rabi v slovenskem kmetijstvu. *Sodobno kmetijstvo*, 37(1), 15–17.

Talvik, M. (2002): Actes de la Conférence paneuropéenne sur l'agriculture et la biodiversité, Conférence organisée par le Conseil de l'Europe en coopération avec le Gouvernement français et la PNUE. 7. 6. 2002, Paris, France, p. 5.

original scientific article
received: 2005-05-05

UDC 595.4:591.9(497.4)

THE HARVESTMEN FAUNA (ARACHNIDA: OPILIONES) FROM THE SUB MEDITERRANEAN REGION OF SLOVENIA – II

Tone NOVAK

University of Maribor, Pedagogical Faculty, Department of Biology, SI-2000 Maribor, Koroška 160

E-mail: tone.novak@uni-mb.si

ABSTRACT

In the present paper, further findings of harvestmen in the Sub Mediterranean region of Slovenia are presented, and comments on some actual problems with the species are added. With the exception of the possible discovery of a troglobitic species in the region, all species living there have presumptively been recorded. With the exclusion of Trogulus gr. nepaeformis and T. gr. tricarinatus, where more species are expected, 34 species and one subspecies have been found in the region. About 20 opilionid species are typical of the region; the others occur in the marginal habitats bordering other zoogeographical regions.

Key words: arachnids, Opiliones, Slovenia, Sub Mediterranean

OPILIONIDI (ARACHNIDA: OPILIONES) DELLA REGIONE SUB-MEDITERRANEA DELLA SLOVENIA – II

SINTESI

L'articolo presenta le nuove scoperte fra gli opilionidi dell'area sub-mediterranea della Slovenia ed alcuni commenti riguardanti i problemi attuali relativi a determinate specie. Siamo probabilmente riusciti a trovare tutte le specie esistenti nell'area, eccezion fatta per le specie troglobie che si presume vivano in questa zona. Senza tenere conto dei Trogulus gr. nepaeformis e dei T. gr. tricarinatus, fra i quali è lecito attendersi l'esistenza di numerose specie, sono state individuate 34 specie ed una sottospecie di opilionidi. Una ventina sono caratteristiche di questa regione, le restanti vivono ai margini degli habitat che confinano con altre regioni zoogeografiche.

Parole chiave: aracnidi, opilionidi, Slovenia, sub-mediterraneo

INTRODUCTION

In our first contribution on harvestmen of the Sub-Mediterranean region of Slovenia (Novak *et al.*, 1995), we counted 33 species and 1 subspecies and discussed the possibility of finding 19 further species. Since 1997, intensive investigations have been carried out in the region due to additional problems. Some of them, like the exclusion of travuniids – *Peltonychia postumicola* (Roewer, 1935) and *P. tenuis* Roewer, 1935 – from the fauna of Slovenia, and the description of the new species *Nelima narcisi*, have been solved by Novak & Gruber (2000), and by Novak & Slana (2003). To date, *Trogulus* gr. *nepaeformis* and *T. gr. tricarinatus* remain the only taxa to be dealt with taxonomically in details.

SYSTEMATIC REVIEW

In the following review (List 1), the system according to Blick & Komposch (2004) was used. The numbers added are the author's current determination numbers.

List 1: Harvestmen (Opiliones) of the Sub-Mediterranean region in Slovenia (according to Novak *et al.*, 1995, and including new records).

Seznam 1: Suhe južine (Opiliones) submediteranske regije v Sloveniji (po Novak *et al.*, 1995, in novih podatkih).

CYPHOPHTHALMI

SIRONIDAE

Siro duricorius duricorius (JOSEPH, 1868)

LANIATORES

PHALANGODIDAE

Scotolemon doriae PAVESI, 1878

PALPATOIRES

NEMASTOMATIDAE

Carinostoma carinatum (ROEWER, 1914)

Histicostoma dentipalpe (AUSSERER, 1867)

Nemastoma bidentatum bidentatum ROEWER, 1914

Nemastoma bidentatum sparsum GRUBER & MARTENS, 1968

Nemastoma dentigerum CANESTRINI, 1873

Mitostoma chrysomelas (HERMANN, 1804)

Paranemastoma quadripunctatum (PERTY, 1833)

DICRANOLASMATIDAE

Dicranolasma scabrum (HERBST, 1799)

TROGULIDAE

Trogulus falcipenis KOMPOSCH, 2000

Trogulus gr. *nepaeformis*

Trogulus gr. *tricarinatus*

Trogulus tingiformis C. L. KOCH, 1847

PHALANGIIDAE

Amilenus aurantiacus (SIMON, 1881)

Dasylobus graniferus (CANESTRINI, 1871)

Lacinius dentiger (C. L. KOCH, 1847)

Lacinius ehippiatus (C. L. KOCH, 1835)

Lacinius horridus (PANZER, 1794)

Lophopilio palpinalis (HERBST, 1799)

Metaphalangium cirtanum (C. L. KOCH, 1839)

Mitopus morio (FABRICIUS, 1799)

Odiellus spinosus (BOSC, 1792)

Oligolophus tridens (C. L. KOCH, 1836)

Opilio dinaricus ŠILHAVÝ, 1938

Opilio saxatilis C. L. KOCH, 1839

Opilio transversalis ROEWER, 1956

Phalangium opilio LINNAEUS, 1758

Platybunus bucephalus (C. L. KOCH, 1835)

SCLEROSOMATIDAE

Astrobonus helleri (AUSSERER, 1867)

Astrobonus laevipes (CANESTRINI, 1872)

Gyas annulatus (OLIVIER, 1791)

Leiobunum roseum C. L. KOCH, 1839

Leiobunum rupestre (HERBST, 1799)

Nelima doriae (CANESTRINI, 1871)

Nelima narcisi NOVAK & SLANA, 2003

Nelima sempronii SZALAY, 1951

REVIEW OF LOCALITIES

CYPHOPHTHALMI

SIRONIDAE

Siro duricorius duricorius (JOSEPH, 1868)

1 km S of the Tolmin - Kobarid - Kamno road crossing, UM91, 200 m, sieving, LS, TN leg., 25.09.1998: 3 mm, 4 ff - 1804/1998.

The species occurs only in the marginal parts of the region, in cold, especially higher places, and has not been reported from deep caves, dolines and the like, although such reports could be expected. It must be taken as a Dinaric species, also for the ecological reason.

LANIATORES

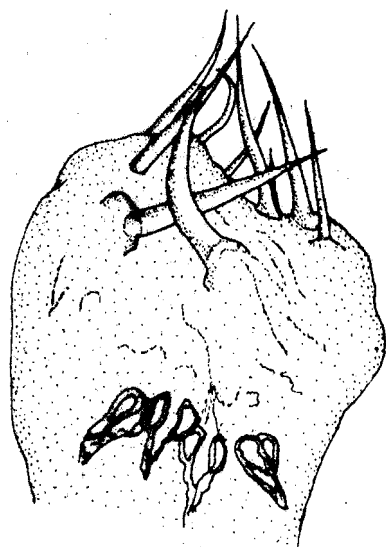
PHALANGODIDAE

Scotolemon doriae PAVESI, 1878

Seča, UL83, *Arundo*, *Rubus*, sieving, brushwood, 1-3 m, LS, TN leg., 10.10.1998: 1 subad. - 1847/1998; *ibid.*, LS, TN leg., 24.10.1998: 5 mm, 5 ff - 1882/1998; *ibid.*, 21.08.1999, MŠ, TN leg.: 2 mm, 3 ff, 1 iuv. - 230/1999. Ovipositor (Fig. 1).

To date, the only known locality of the species in Slovenia is an old heap of discarded orchard tree branches, overgrown especially with *Arundo donax* and *Rubus* sp. Over the years, a layer of humus more than

10 cm deep arose, hosting a population of the species. This is a case of an anthropogenous habitat, unintentionally serving as a refuge, and replacing the appropriate natural habitats in land otherwise much domesticated with no more of these habitats. Branch heaps also serve as refuges in commercially managed woodland in inland Slovenia.



100 µm

Fig. 1: *Scotolemon doriae*, the ovipositor tip with the receptacula seminis (Seča, 21.08.1999).

Sl. 1: *Scotolemon doriae*, leglica s semenskimi vrečkami (Seča, 21.08.1999).

PALPATOIRES

NEMASTOMATIDAE

Carinostoma carinatum (ROEWER, 1914)

Breg, Grgar, UL99, *Corylus*, *Tilia*, *Ostrya*, litter sieving, 02.08.2000, TN leg.: 1 m, 1 f - 337/2000; 250 m SE of Zabrdó (Grgar), UL99, *Quercus*, *Fraxinus*, sieving, 02.08.2000, TN leg.: 2 mm - 308/2000; Britof - Ukanje, UM80, litter, 09.08.2000, TN leg.: 1 m - 519/2000; 400 m SW of Lovišče, Britof, UM90, *Fagetum* edge, sieving, 09.08.2000, TN leg.: 3 mm, 1 f - 524/2000; 300 m W of Proj, Brdice near Kožbana, UM80, along the Kožbanjšček stream, *S. aria*, *Fraxinus*, *Robinia*, *Corylus*, forest edge, sieving, 09.08.2000, TN leg.: 1 f - 525/2000; 300 m SSE of Senik, UM80, *Ostrya*, sieving, 09.08.2000, TN leg.: 1 m, 4 ff - 512/2000; Doblar, UM90, *Fraxinus*, *Acer*, *Robinia*, litter sieving, 02.08.2000, TN leg.: 3 mm, 4 ff, 1 iuv. - 287/2000; Gornje Nakovo, UM90, *Ostrya*, grass, sieving, 09.08.2000, TN leg.: 1 m - 553/2000; Lepenka valley, UM90, Doblar, on a limestone wall, 25.09.1998, LS, TN leg.: 1 m, 3 ff - 1794/1998; Levpa - Seniški breg, UM90, *Ulmus*, *Fraxinus*, *Juglans*, sieving, 02.08.2000,

TN leg.: 2 mm, 2 ff - 320/2000; Marija Snežna, UM90, *Luzula silvestris*, grass, sieving, 02.08.2000, TN leg.: 1 f - 294/2000; Boršt, VL03, 02.04.1995, SP leg.: 1 f - 661/1998; Brestovica, VL16, Povir, 420 m, 10.03.1994, SB leg.: 1 f - 639/1998.

Common species in deep humus soils.

Histicostoma dentipalpe (AUSSERER, 1867)

Dry water bed of a tributary of the Dragonja river, UL93, below Abrami, *Carpinus* itd., sieving, 19.07.1999, LS, TN leg.: 3 iuv. - 149/1999; St. Duh, UL93, Padna, sieving, *Quercus*, grass, beneath stones, 19.07.1999, LS, TN leg.: 1 iuv. - 153/1999; Livške Ravne, UM91, sieving, 08.08.2000, TN leg.: 1 m, 1 f - 534/2000; 300 m SE Solarji, UM91, *Ostrya*, *Fraxinus*, 08.08.2000, TN leg.: 1 m, 1 f - 561/2000; Tublje near Hrpelje, VL15, *Carpinus*, *Tilia*, forest edge meadow, beneath stones, 20.07.1999, LS, TN leg.: 2 iuv. - 176/1999; Goče, VL17, along the Branica stream, 11.07.1997, 200 m, on *Apodemus flavicollis*, TT leg.: 1 pullus - 278/2000.

The possibility that the attachment of a young *H. dentipalpe* on the *Apodemus* is a case of a phoresy, must be proved by further findings, as it was found on a dead mouse within a trap (T. Trilar, pers. comm.).

Nemastoma bidentatum bidentatum ROEWER, 1914

Panovec, UL98, Nova Gorica, near the forester's cabin, 17.08.2000, TN leg.: 1 m, 2 ff - 668/2000; Replje, UL98, Vogrsko, 08.04.1992, SB leg.: 1 m - 649/1998; near the bridge at Doblar power station, UM90, *Fraxinus*, *Acer*, *Robinia*, litter sieving, 02.08.2000, TN leg.: 2 mm - 285/2000; 300 m SE of Solarji, UM91, *Ostrya*, *Fraxinus*, 08.08.2000, TN leg.: 1 m, 3 ff - 562/2000; Šmarje - Štanjel - Hrastje, VL07, grass, sieving, 17.08.2000, TN leg.: 4 ff - 674/2000; 500 m S of Velike Žablje, VL07, *Acer*, *Robinia*, sieving, 17.08.2000, TN leg.: 1 f - 677/2000; Lepenka valley, UM90, Doblar, on a limestone wall, 25.09.1998, LS, TN leg.: 1 m - 1795/1998; 1 km S of the Tolmin - Kobarid - Kamno road crossing, UM91, 200 m, sieving, 31.07.1998, LS, TN leg.: 2 mm - 1337/1998; *ibid.*, 25.09.1998, LS, TN leg.: 1 m, 1 f - 1809/1998; Mt. Vremščica, VL26, 640 m, 10.03.1994, SB leg.: 1 f - 680/1998.

The species is sparsely distributed in northern localities; it is not common in the Sub-Mediterranean.

Nemastoma bidentatum sparsum GRUBER & MARTENS, 1968

Along the Medljanščica stream, UL93, 1 km W Padna, 22.06.2000, litter sieving, *Ostryetum*, BB, BO, TN leg.: 1 m - 217/2000; 100 m E of stone plates in the Dragonja river bed, UL93, *Arundo*, grass, sieving, 20.07.1999, LS, TN leg.: 1 f - 194/1999; 200 m S of the Koper -

Dragonja - Ivankovec road crossing, UL93, 20 m, dry stream bed, sieving, 23.09.1998, LS, TN leg.: 2 mm, 3 ff - 1791/1998; Korte, UL93, 60 m, *Ostryetum*, 23.09.1998, LS, TN leg.: 1 m - 1821/1998; along the Medjanščica stream, UL93, brush shrubs, 21.08.1999, TN leg.: 33 mm, 30 ff - 239/1999; Padna, UL93, 19.07.1999, sieving, *Cotinus*, *Rubus*, *Q. pubescens*, LS, TN leg.: 1 m - 168/1999; Seča, UL93, *Arundo*, sieving, 1-3 m, 10.10.1998, LS, TN leg.: 1 f - 1844/1998; *ibid.*, *Arundo*, 1-3 m, sieving, LS, TN leg., 24.10.1998: 1 m, 1 f - 1881/1998; *ibid.*, *Arundo*, *Rubus* itd.; *ibid.*, sieving, brushwood, 21.08.1999, MŠ, TN leg.: 15 mm, 21 ff - 231/1999; *ibid.*, *Ostrya*, *Quercus* itd.; sieving, brushwood, 21.08.1999, MŠ, TN leg.: 3 ff - 236/1999; St. Peter (Raven), UL93, 220 m, *Quercus*, grass, sieving, 11.10.1998, LS, TN leg.: 1 m - 1850/1998; dry bed of the Dragonja river, UL93, ca. 500 m SW of Abrami, *Carpinetum*, sieving, 19.07.1999, LS, TN leg.: 4 ff, 1 iuv. - 148/1999; *ibid.*, sieving, 20.07.1999, LS, TN leg.: 2 ff - 188/1999; St. Duh, UL93, Padna, sieving, *Quercus*, grass, beneath stones, 19.07.1999, LS, TN leg.: 4 mm, 2 ff - 151/1999; ca. 1 km E of Ankaran, VL04, 29.09.1999, sieving, LS, TN leg.: 1 f - 5/1999; Hrpelje, VL14, 520 m, 02.04.1993, SB leg.: 1 m - 651/1998.

The subspecies is disjunctively and sparsely distributed in the Sub Mediterranean region of Slovenia. The hybrids between both subspecies would also be expected in the region.

Nemastoma dentigerum CANESTRINI, 1873

Lucija - Seča - Debernardo, UL93, *Arundo*, peach orchard, dry grass, beneath stones, 22.09.1998, LS, TN leg.: 1 f - 1817/1998; along the Medjanščica stream, UL93, 1 km W of Padna, 22.06.2000, litter sieving, *Ostryetum*, BB, BO, TN leg.: 1 f - 218/2000; Novelo - Kostanjevica na Krasu, UL97, *Castanea*, sieving, 17.08.2000, TN leg.: 1 f - 662/2000; Grgar, UL99, shrubs, cemetery, litter sieving, 02.08.2000, TN leg.: 1 m, 1 f - 341/2000; 350 m NE of Grgarske Ravne, UL99, *Tilia*, *Corylus*, *Fraxinus*, sieving, 02.08.2000, TN leg.: 1 m - 316/2000; 250 m SE of Zabrdno (Grgar), UL99, *Quercus*, *Fraxinus*, sieving, 02.08.2000, TN leg.: 1 m - 307/2000; 1,5 km N of Senik, UM80, *Fraxinus*, *Alnus*, sieving, 09.08.2000, TN leg.: 1 m - 521/2000; 300 m SSE of Senik, UM80, *Ostrya*, sieving, 09.08.2000, TN leg.: 3 mm, 2 ff - 513/2000; Velendol, UM80, *Tilia*, beneath stones, sieving, 09.08.2000, TN leg.: 1 f - 517/2000; Avče, UM90, *Corylus*, *Tilia*, grass, 02.08.2000, TN leg.: 2 ff - 298/2000; near the bridge at Doblar power station, UM90, *Fraxinus*, *Acer*, *Robinia*, litter sieving, 02.08.2000, TN leg.: 1 m, 4 ff - 284/2000; Gornje Nakovo, UM90, *Ostrya*, grass, sieving, 09.08.2000, TN leg.: 2 mm, 2 ff - 554/2000; Levpa - Seniški breg, UM90, *Ulmus*, *Fraxinus*, *Juglans*, sieving, 02.08.2000, TN leg.: 1 m - 319/2000; 350 m NNW of Lig,

UM90, *Ostrya*, *Tilia*, sieving, 09.08.2000, TN leg.: 4 mm, 1 f - 508/2000; 400 m SW of Lovišče, Britof, UM90, *Fagetum* edge, sieving, 09.08.2000, TN leg.: 1 f - 523/2000; Marija Snežna, UM90, *Luzula silvestris*, grass, sieving, 02.08.2000, TN leg.: 1 f - 293/2000; Livške Ravne, UM91, sieving, 08.08.2000, TN leg.: 1 m - 535/2000; 1 km S of the Tolmin - Kobarid - Kamno road crossing, UM91, 200 m, sieving, 25.09.1998, LS, TN leg.: 10 mm, 5 ff - 1808/1998; *ibid.*, 31.07.1998: 2 mm, 4 ff - 1338/1998; Ladra, UM92, 50 m from the Soča river, forest edge, litter sieving, 25.09.1998, LS, TN leg.: 1 m - 1811/1998; Tublje pri Hrpeljah, VL15, *Carpinus*, *Tilia*, forest edge meadow, beneath stones, 20.07.1999, LS, TN leg.: 7 mm, 1 f - 174/1999.

Common species in deep humus soils.

Mitostoma chrysomelas (HERMANN, 1804)

200 m S of the Koper - Dragonja - Ivankovec road crossing, UL93, 20 m, dry water bed, sieving, 23.09.1998, LS, TN leg.: 2 iuv. - 1789/1998; along the Medjanščica stream, UL93, Padna - Korte, brushwood, 21.08.1999, TN leg.: 2 ff - 238/1999; ca. 300 m SE of St. Onofrij, Parecag, UL93, 19.07.1999, LS, TN leg.: 2 ff - 160/1999; Padna, UL93, 19.07.1999, sieving, *Cotinus*, *Rubus*, *Q. pubescens*, LS, TN leg.: 1 f - 167/1999; Seča, UL93, *Arundo*, *Rubus* itd.; sieving, brushwood, 21.08.1999, MŠ, TN leg.: 2 mm, 1 f, 1 iuv. - 229/1999; Sečovelje wine cellar 107, UL93, ca. 400 m N of St. Onofrij, 19.07.1999, grass near a wall, LS, TN leg.: 1 f - 147/1999; near the bridge at Doblar power station, UM90, *Fraxinus*, *Acer*, *Robinia*, litter sieving, 02.08.2000, TN leg.: 1 f - 281/2000; Zarečica - Koseze - V. Bukovica, VL34, 22.08.1998, forest edge meadow, 22.08.1998, LS, TN leg.: 1 f - 1518/1998.

This common species is sparsely distributed in the Sub Mediterranean region of Slovenia in well-spaced, humid habitats, like brushwood and stone heaps.

Paranemastoma quadripunctatum (PERTY, 1833)

Near the bridge at Doblar power station, UM90, *Fraxinus*, *Acer*, *Robinia*, litter sieving, 02.08.2000, TN leg.: 1 m - 282/2000; 350 m NNW of Lig, UM90, *Ostrya*, *Tilia*, sieving, 09.08.2000, TN leg.: 2 ff - 510/2000; Marija Snežna, UM90, *Luzula silvestris*, grass, sieving, 02.08.2000, TN leg.: 1 m, 1 f - 290/2000; Livške Ravne, UM91, sieving, 08.08.2000, TN leg.: 1 m, 1 f - 533/2000; Na Gradu, UM91, grass, 08.08.2000, TN leg.: 2 mm - 540/2000; 1 km S of the Tolmin - Kobarid - Kamno road crossing, UM91, 200 m, sieving, 31.07.1998, LS, TN leg.: 1 f - 1336/1998; *ibid.*, 25.09.1998: 2 pulli - 1803/1998.

The species occurs only in the marginal parts of the region, in cold, especially higher localities; it is not common in the Sub Mediterranean.

DICRANOLASMATIDAE

Dicranolasma scabrum (HERBST, 1799)

450 m SWW of Stan, UL99, Grgar - Čepovan, *Corylus*, *Fagus*, litter sieving, 02.08.2000, TN leg.: 1 f - 333/2000; Avče, UM90, *Corylus*, *Tilia*, grass, 02.08.2000, TN leg.: 2 ff - 297/2000; near the bridge at Doblar power station, UM90, *Fraxinus*, *Acer*, *Robinia*, litter sieving, 02.08.2000, TN leg.: 1 iuv. - 283/2000; Gornje Nakovo, UM90, *Ostrya*, grass, sieving, 09.08.2000, TN leg.: 1 m - 552/2000; Lepenka valley, UM90, Doblar, on a limestone wall, 25.09.1998, LS, TN leg.: 2 ff - 1831/1998; Marija Snežna, UM90, *Luzula silvestris*, grass, sieving, 02.08.2000, TN leg.: 2 mm - 291/2000; Nagnoj, UM91, grass, 08.08.2000, TN leg.: 1 f - 558/2000; Na Gradu, UM91, grass, 08.08.2000, TN leg.: 1 m - 541/2000; 1 km S of the Tolmin - Kobarid - Kamno road crossing, UM91, 200 m, sieving, LS, TN leg., 31.07.1998: 1 m - 1335/1998; Štorje, VL16, Griže, 590 m, 02.04.1993, SB leg.: 1 f - 635/1998.

The species is sparsely distributed in dry places at higher altitudes; it is not common in the Sub Mediterranean.

TROGULIDAE

Trogulus falcipenis KOMPOSCH, 2000

1 km S of the Tolmin - Kobarid - Kamno road crossing, UM91, 200 m, sieving, LS, TN leg., 31.07.1998: 1 m - 1333/1998.

This Dinaric and East-Alpine species (Komposch, 2000) is not common in Sub Mediterranean.

Trogulus gr. *nepaeformis*

200 m S of the Koper - Dragonja - Ivankovec crossing, UL93, 20 m, dry water bed, sieving, 23.09.1998, LS, TN leg.: 7 iuv. - 1790/1998; Korte, UL93, 350 m NNW of Parecag, 60 m, *Ostryetum*, 23.09.1998, LS, TN leg.: 1 f - 1823/1998; along the Medjanščica stream, UL93, Padna - Korte, *Ostryetum*, brushwood, 21.08.1999, TN leg.: 17 mm, 7 ff, 6 iuv. - 241/1999; *ibid.*, 22.06.2000, litter sieving, BB, BO, TN leg.: 1 f - 216/2000; Dragonja valley, 600 m E of Abrami, UL93, 21.06.2000, *Quercus*, litter, dry bed of the Dragonja river, BB, BO, TN leg.: 3 iuv. - 219/2000; 1 km W of Novi Brič (312 m), UL93, the road crossing for Puče, 110 m, 11.10.1998, LS, TN leg.: 2 ff, 2 iuv. - 1840/1998; Seča, UL93, *Arundo*, sieving, 1-3 m, 10.10.1998, LS, TN leg.: 2 mm, 1 f - 1845/1998; *ibid.*, *Arundo*, *Rubus* itd.; sieving, brushwood, 21.08.1999, MŠ, TN leg.: 2 mm, 1 f, 3 iuv. - 232/1999; Korita na Krasu, UL97, sieving, forest edge, 17.08.2000, TN leg.: 1 f, 2 iuv. - 659/2000; Lipa - Temnica, UL97, sieving, forest edge, 17.08.2000, TN leg.: 1 iuv. - 666/2000; Bazara, UL98, Volčja Draga, *Quercus*, *Ostrya*, *Robinia*, *Fraxinus*, sieving, 27.08.2000, TN leg.: 2 ff, 1 iuv. - 697/2000; Panovec, UL98,

Nova Gorica, near the forester's cabin, 17.08.2000, TN leg.: 3 mm, 5 ff, 3 iuv. - 667/2000; Breg, Grgar, UL99, *Corylus*, *Tilia*, *Ostrya*, litter sieving, 02.08.2000, TN leg.: 1 iuv. - 336/2000; Grgar, UL99, shrubs, cemetery, litter sieving, 02.08.2000, TN leg.: 1 f, 2 iuv. - 338/2000; 350 m NE of Grgarske Ravne, UL99, *Tilia*, *Corylus*, *Fraxinus*, sieving, 02.08.2000, TN leg.: 1 m, 2 ff - 317/2000; 250 m SE of Zabrdó, Grgar, UL99, *Quercus*, *Fraxinus*, sieving, 02.08.2000, TN leg.: 1 f, 1 iuv. - 310/2000; 300 m SSE of Senik, UM80, *Ostrya*, sieving, 09.08.2000, TN leg.: 1 m, 3 ff, 6 iuv. - 511/2000; 300 m W of Proj, Brdice pri Kožbani, UM80, by the Kožbanjšček stream, *S. aria*, *Fraxinus*, *Robinia*, *Corylus*, forest edge, sieving, 09.08.2000, TN leg.: 2 mm, 3 iuv. - 527/2000; Avče, UM90, *Corylus*, *Tilia*, grass, brushwood, 02.08.2000, TN leg.: 2 mm - 299/2000; near the bridge at Doblar power station, UM90, *Fraxinus*, *Acer*, *Robinia*, litter sieving, 02.08.2000, TN leg.: 5 mm, 1 f, 3 iuv. - 288/2000; Gornje Nakovo, UM90, *Ostrya*, grass, sieving, 09.08.2000, TN leg.: 1 m, 1 iuv. - 551/2000; 350 m NNW of Lig, UM90, *Ostrya*, *Tilia*, sieving, 09.08.2000, TN leg.: 2 ff, 1 iuv. - 509/2000; 400 m SW of Lovišče, Britof, UM90, *Fagetum* edge, sieving, 09.08.2000, TN leg.: 3 mm, 2 ff - 522/2000; Marija Snežna, UM90, *Luzula silvestris*, grass, sieving, 02.08.2000, TN leg.: 1 m, 3 ff, 1 subad. - 292/2000; Lepenka valley, UM90, Doblar, litter sieving, 25.09.1998, LS, TN leg.: 1 m, 3 ff, 12 iuv. - 1796/1998; Sukavec, UM90, grass, 02.08.2000, TN leg.: 1 m - 305/2000; Livške Ravne, UM91, sieving, 08.08.2000, TN leg.: 1 m, 2 ff - 536/2000; 300 m SE Solarji, UM91, *Ostrya*, *Fraxinus*, 08.08.2000, TN leg.: 1 f, 2 iuv. - 559/2000; 1 km S of the Tolmin - Kobarid - Kamno road crossing, UM91, 200 m, sieving, 25.09.1998, LS, TN leg.: 3 mm, 4 ff, 7 iuv. - TN 1807/1998; Ladra, UM92, 50 m from the Soča river, forest edge, litter sieving, 25.09.1998, LS, TN leg.: 1 f - 1810/1998; Župančiči - Fiejeroga, VL03, under stones, 230 m, 10.11.1998, LS, TN leg.: 1 m - 1856/1998; ca. 1 km E of Ankarán, VL04, 29.09.1999, sieving, LS, TN leg.: 1 iuv. - 6/1999; Šmarje - Štanjel - Hrastje, VL07, grass, sieving, 17.08.2000, TN leg.: 1 m, 1 f - 673/2000; 500 m S Velike Žablje, VL07, *Acer*, *Robinia*, sieving, 17.08.2000, TN leg.: 2 ff, 1 iuv. - 676/2000; Čaven, VL08, Trnovski gozd, at the alpine chalet, 11.07.1995, TN leg.: 1 m - 98/1997; *ibid.*, Veverica, VL08, under stones, 18.06.1999, TN leg.: 2 mm - 56/1999; Mt. Slavnik, VL14, *Coryletum/Fagetum*, 21.06.2000, litter, below the peak of Grmada, BB, BO, TN leg.: 4 mm, 3 ff, 3 iuv. - 107/2000; Povir, VL16, Brestovica, 420 m, 10.03.1994, SB leg.: 1 iuv. - 638/1998; Štorje, VL16, Griže, 590 m, 02.04.1993 SB leg.: 1 m - 634/1998; Vrabče, VL17, Podnanos, 300 m, 10.03.1994, SB leg.: 2 iuv. - 631/1998; Bač pri Materiji, VL24, LS, TN leg., 24.10.1998: 1 f - 1883/1998; Materija, VL24, litter sieving, under stones, 24.05.1995, LS, TN leg.: 1 m, 1 iuv. - 90/1997; Medvedjak, VL24, Kozina, Notranjski muzej

Postojna No. O-039, 11.04.1992, SP leg.: 2 mm - 644/1998; Bača pri Modreju, VM01, *Ostrya*, grass, sieving, 09.08.2000, TN leg.: 1 iuv. - 557/2000.

In both troguli groups, *T. gr. nepaeformis* and *T. gr. tricarinatus*, the revisions at the genetic level have started (Martens in litt; Schönhofer, 2004)

Trogulus gr. tricarinatus

Korita na Krasu, UL97, sieving, forest edge, 17.08.2000, TN leg.: 1 m - 660/2000; 250 m SE of Zabrdro (Grgar), UL99, *Quercus*, *Fraxinus*, sieving, 02.08.2000, TN leg.: 1 m - 309/2000; Lepenka valley, UM90, Doblar, litter sieving, 25.09.1998, LS, TN leg.: 1 iuv. - 1797/1998; Mt. Slavnik, VL14, 21.06.2000, litter, *Coryletum/Fagetum*, below the peak of Grmada, BB, BO, TN leg.: 2 mm, 1 f - 108/2000; Šmarje - Štanjel - Hrastje, VL07, grass, sieving, 17.08.2000, TN leg.: 1 f - 672/2000.

Trogulus tingiformis C. L. KOCH, 1847

1 km S of the Tolmin - Kobarid - Kamno crossing, UM91, 200 m, sieving, LS, TN leg., 25.09.1998: 1 iuv. - 1806/1998.

This species is also in need of revision.

PHALANGIIDAE

Amilenus aurantiacus (SIMON, 1881)

Ponor polne Lune pothole, UM90, - 60 m, Kanalski vrh, 04.05.1997, SP leg.: 1 f - 653/1998; 1 km S of the crossing Tolmin - Kobarid - Kamno, UM91, 200 m, sieving, LS, TN leg., 25.09.1998: 1 iuv. - 1800/1998; Idrsko - Livek, UM92, 08.08.2000, TN leg.: 1 iuv. - 529/2000; 1 km N of Sušak, VL34, 640 m, under the bridge, 07.11.1998, LS, TN leg.: 1 subad. - 1889/1998.

The species occurs in the marginal parts of the region, in cold places, especially at higher altitudes; it is not common in the Sub Mediterranean.

Dasylobus graniferus (CANESTRINI, 1871)

Čaven, VL08, Trnovski gozd, near the alpine chalet, 11.07.1995, TN leg.: 1 m - 93/1997; Kucelj, VL08, Trnovski gozd, 14.07.1996, TN leg.: 1 m - 12/1997.

The species is sparsely distributed at higher altitudes; it is not common in the Sub Mediterranean.

Lacinius dentiger (C. L. KOCH, 1847)

Mrzli studenec, 260 m, UL93, 350 m E of the Padna - Nova vas - Križišče crossing, 23.09.1998, LS, TN leg.: 1 f - 1816/1998; the mountain chalet below Ježa (949 m), UM91, on walls, 08.08.2000, TN leg.: 2 iuv. - 537/2000; Čaven, VL08, Trnovski gozd, near the alpine chalet, 11.07.1995, TN leg.: 1 iuv. - 96/1997; Mt. Slav-

nik, VL14, 21.06.2000, litter, *Coryletum/Fagetum*, below the peak of Grmada, BB, BO, TN leg.: 1 iuv. - 110/2000; 1 km N of Sušak, VL34, 640 m, under the bridge, 07.11.1998, LS, TN leg.: 2 mm - 1888/1998.

This oligothermophilous species occurs in the marginal parts of the region, especially at higher altitudes, and proves to be hygrophilous in the region; it is not common in the Sub Mediterranean.

Lacinius ephippiatus (C. L. KOCH, 1835)

Čaven, VL08, Trnovski gozd, near the alpine cabin, 11.07.1995, TN leg.: 2 iuv. - 95/1997; Kucelj, VL08, Trnovski gozd, 11.05.1995, TN leg.: 1 iuv. - 91/1997; Grgar, UL99, shrubs, cemetery, litter sieving, 02.08.2000, TN leg.: 1 f - 339/2000; 350 m NE of Grgarske Ravne, UL99, *Tilia*, *Corylus Fraxinus*, sieving, 02.08.2000, TN leg.: 2 ff - 315/2000.

The hygrophilous species is sparsely distributed within the Sub Mediterranean region, but it is common at higher altitudes.

Lacinius horridus (PANZER, 1794)

Čedola, UL93, grass near the Jernejski potok stream, 50 m, 11.10.1998, LS, TN leg.: 2 mm, 1 f - 1866/1998; Kaštinjol, UL93, grass, 11.10.1998, LS, TN leg.: 2 mm - 1869/1998; Korte, UL93, 350 m N-NW Parecag, 60 m, *Ostryetum*, 23.09.1998, LS, TN leg.: 1 m - 1824/1998; Lucija - Seča - Debernardo, UL93, *Arundo*, peach orchard, dry grass, under stones, 22.09.1998, LS, TN leg.: 2 ff - 1818/1998; Mrzli studenec, 300 m, UL93, 300 m E of the Padna - Nova vas - Križišče crossing, 23.09.1998, LS, TN leg.: 1 m, 1 f - 1815/1998; ca. 150 m SE of St. Onofrij, Parecag, UL93, 110 m, 19.07.1999, LS, TN leg.: 4 iuv. - 170/1999; *ibid.*: 1 iuv. - 162/1999; Padna, UL93, sieving, *Cotinus*, *Rubus*, *Q. pubescens*, 19.07.1999, LS, TN leg.: 1 iuv. - 166/1999; Pišine, UL93, near the Drnica stream, grass around a tree, 19.07.1999, LS, TN leg.: 2 iuv. - 154/1999; *ibid.*: 1 iuv. - 159/1999; *ibid.*, 28.09.1999: 1 m, 1 iuv. - 250/1999; grass near stone plates in the Dragonja river bed, UL93, below Abrami, 19.07.1999, LS, TN leg.: 2 iuv. - 143/1999; 100 m E of stone plates in the Dragonja river bed, UL93, *Arundo*, grass, sieving, 20.07.1999, LS, TN leg.: 3 iuv. - 191/1999; Sečovelje wine cellar 107, UL93, 19.07.1999, grass near a wall, LS, TN leg.: 1 iuv. - 146/1999; Korita na Krasu, UL97, sieving, forest edge, 17.08.2000, TN leg.: 1 iuv. - 658/2000; ca. 500 m SE of Preval, UM90, Ročinj, forest edge, 26.09.1998, LS, TN leg.: 1 f - 1799/1998; Sukavec, UM90, grass near a rock wall, 02.08.2000, TN leg.: 3 iuv. - 304/2000; 500 m E of the Koper - Ljubljana - Ankaran road crossing, VL04, *Arundo*, *Clematis*, *Urtica*, 23.09.1998, LS, TN leg.: 1 iuv. - 1784/1998; 300 m W of Miši (Dekani), VL04, on the bridge over the Rižana river, 20 m, 11.10.1998, LS,

TN leg.: 2 mm - 1832/1998; Čaven, Veverica, VL08, Trnovski gozd, under stones, 18.06.1999, TN leg.: 1 iuv. - 57/1999; Mt. Slavník, VL14, litter, *Coryletum/Fagetum*, below the peak of Grmada, 21.06.2000, BB, BO, TN leg.: 1 iuv. - 109/2000.

This is a common species in the Sub Mediterranean region of Slovenia.

Lophopilio palpinalis (HERBST, 1799)

Grgar, UL99, shrubs, cemetery, litter sieving, 02.08.2000, TN leg.: 1 iuv. - 340/2000; Gornje Nakovo, UM90, *Ostrya*, grass, sieving, 09.08.2000, TN leg.: 1 iuv. - 555/2000; Na Gradu, UM91, grass, 08.08.2000, TN leg.: 2 iuv. - 539/2000; 300 m SE of Solarji, UM91, *Ostrya*, *Fraxinus*, 08.08.2000, TN leg.: 3 iuv. - 560/2000; 1 km S of the Tolmin - Kobarid - Kamno road crossing, UM91, 200 m, sieving, LS, TN leg.: 31.07.1998: 1 iuv. - 1334/1998; *ibid.*, 25.09.1998: 1 m - 1801/1998; Mt. Slavník, VL14, litter, *Coryletum/Fagetum* pod Grmado, 21.06.2000, BB, BO, TN leg.: 1 iuv. - 111/2000; Materija, VL24, litter sieving, beneath stones, 24.05.1995, LS, TN leg.: 1 pullus - 89/1997; Zarečica, along the Molja torrent, VL34, *Mentha*, *Urtica*, 22.08.1998, LS, TN leg.: 2 iuv. - 1525/1998; Zarečica - Koseze - Velika Bukovica, VL34, forest edge meadow, 22.08.1998, LS, TN leg.: 2 iuv. - 1517/1998.

The species is sparsely distributed within the Sub Mediterranean region, but common at higher altitudes.

Mitopus morio (FABRICIUS, 1799)

Livške Ravne, UM91, sieving, 08.08.2000, TN leg.: 1 m - 532/2000; Čaven, VL08, Trnovski gozd, near the alpine chalet, 11.07.1995, TN leg.: 1 subad., 1 iuv. - 94/1997; Kucelj, VL08, Trnovski gozd, 11.05.1995, TN leg.: 1 iuv. - 92/1997; *ibid.*, 14.07.1996: 2 ff - 11/1997.

The species is not common in the Sub Mediterranean region, although it occurs frequently at higher altitudes.

Oligolophus tridens (C. L. KOCH, 1836)

Zarečica - Koseze - Velika Bukovica, VL34, forest edge meadow, 22.08.1998, LS, TN leg.: 1 m, 2 ff, 2 iuv. - 1520/1998.

This hygrophilous species is not common in the Sub Mediterranean region; it occurs, however, at higher marginal localities.

Odiellus spinosus (BOSC, 1792)

Below Abrami, UL93, grass, 19.07.1999, LS, TN leg.: 1 iuv. - 177/1999; Čedola, UL93, grass near the Jernejski potok stream, 50 m, 11.10.1998, LS, TN leg.: 1 m - 1867/1998; Fenendra, UL93, Draga, grass, 22.08.1999, MŠ, TN leg.: 1 iuv. - 225/1999; 1 km W of Novi Brič

(312 m), UL93, the road crossing for Puče, 110 m, 11.10.1998, LS, TN leg.: 1 m - 1841/1998; ca. 150 m SE of St. Onofrij, Parecag, UL93, 110 m, 19.07.1999, LS, TN leg.: 1 iuv. - 169/1999; 300 m SE of St. Onofrij, UL93, 110 m, under stones, LS, TN leg.: 10.10.1998: 1 m - 1836/1998; *ibid.*, 02.09.2000: 2 iuv. - 702/2000; *ibid.*, 19.07.1999: 1 iuv. - 161/1999; *ibid.*, 21.08.1999, grass, TN leg.: 1 iuv. - 227/1999; 900 m SSE of Paderno (Seča), UL93, 5 m, near the bridge, 10.10.1998, LS, TN leg.: 2 mm - 1853/1998; Padna, UL93, 19.07.1999, sieving, *Cotinus*, *Rubus*, *Q. pubescens*, LS, TN leg.: 1 iuv. - 165/1999; 500 m E of Padna, UL93, 220 m, beneath stones, 23.09.1998, LS, TN leg.: 2 mm, 2 ff - 1783/1998; Pišine, UL93, near the bridge over the Drnica stream, grass around a tree, 19.07.1999, LS, TN leg.: 2 iuv. - 155/1999; *ibid.*, 28.09.1999: 1 m - 249/1999; Seča, UL93, dry grass, 23.09.1998, LS, TN leg.: 2 mm, 2 ff, 1 subad. - 1814/1998; Sečoveljske soline (Sečovelje salt pans), UL93, 100 m W of Droga, 1-2 m, 10.10.1998, LS, TN leg.: 2 mm - 1873/1998; St. Duh, UL93, Padna, sieving, *Quercus*, grass, beneath stones, 19.07.1999, LS, TN leg.: 2 iuv. - 152/1999; St. Peter (Raven), UL93, 220 m, *Quercus*, grass, sieving, 11.10.1998, LS, TN leg.: 1 f - 1852/1998; drainage ditch S of Šempeter, UL98, 17.08.2000, TN leg.: 1 iuv. - 680/2000; Župančiči - Fiejeroga, VL03, beneath stones, 230 m, 10.11.1998, LS, TN leg.: 1 f - 1857/1998; Saksid, VL08, along the Vipava river, 17.08.2000, TN leg.: 1 f, 1 subad. - 684/2000; Ajdovščina - Vipavski Križ, VL18, near the influx of the Hubelj river, brushwood, 17.08.2000, TN leg.: 1 f, 1 subad. - 665/2000; Vipavski Križ - Cesta, VL18, cemetery, 17.08.2000, TN leg.: 1 f - 679/2000.

This is a common species in the Sub Mediterranean region of Slovenia.

Opilio dinaricus ŠILHAVÝ, 1938

Along the Medljanščica stream, UL93, 1 km W of Padna, litter, *Ostryetum*, sieving, 22.06.2000, BB, BO, TN leg.: 2 mm, 2 ff - 215/2000; Kucelj, VL08, Trnovski gozd, 14.07.1996, TN leg.: 2 iuv. - 13/1997; *ibid.*, 07.06.1997: 3 iuv. - 426/1998; *ibid.*, under stones, 18.06.1999, TN leg.: 1 iuv. - 58/1999.

The species is sparsely distributed within the Sub Mediterranean region, but common at higher altitudes.

Opilio saxatilis C. L. KOCH, 1839

Čedola, UL93, near the Jernejski potok stream, 50 m, grass, 11.10.1998, LS, TN leg.: 2 mm, 1 f - 1868/1998; 1 km E of Dragonja, UL93, grass, 40 m, 11.10.1998, LS, TN leg.: 1 m, 1 f, 1 iuv. - 1838/1998; 2 km E of Dragonja, UL93, 40 m, grass, 11.10.1998, LS, TN leg.: 1 iuv. - 1864/1998; Grič, 3 km E of Dragonja, UL93, 40 m, 11.10.1998, LS, TN leg.: 1 m, 1 f - 1834/1998;

Kaštinjol, UL93, grass, 11.10.1998, LS, TN leg.: 3 mm - 1871/1998; Nova vas, 260 m, UL93, meadow, 11.10.1998, LS, TN leg.: 9 mm, 2 ff, 1 iuv. - 1862/1998; 1 km W of Novi Brič (312 m), UL93, the road crossing for Puče, 110 m, 11.10.1998, LS, TN leg.: 1 m - 1842/1998; 900 m SSE of Paderno (Seča), UL93, 5 m, at the bridge, LS, TN leg., 10.10.1998: 3 mm, 3 ff - 1855/1998; 500 m E of Padna, UL93, under stones, 220 m, 23.09.1998, LS, TN leg.: 1 f - 1876/1998; Pišine, UL93, grass around a tree, 28.09.1999, LS, TN leg.: 3 mm, 3 ff - 253/1999; Seča, UL83, *Arundo*, sieving, 1-3 m, LS, TN leg., 10.10.1998: 1 m, 1 f - 1848/1998; Sečoveljske soline, UL93, 1-2 m, 100 m W of Droga, 10.10.1998, LS, TN leg.: 1 m - 1874/1998; St. Peter (Raven), UL93, 220 m, *Quercus*, grass, sieving, 11.10.1998, LS, TN leg.: 1 m - 1851/1998; Župančiči - Fiejeroga, VL03, under stones, 230 m, 10.11.1998, LS, TN leg.: 1 m, 1 f - 1858/1998; 500 m E of the Koper - Ljubljana - Ankaran road crossing, VL04, *Arundo*, *Clematis*, *Urtica*, 23.09.1998, LS, TN leg.: 2 ff, 2 iuv. - 1787/1998; Saksid, VL08, along the Vipava river, 17.08.2000, TN leg.: 1 iuv. - 687/2000.

This thermophilous species is common in the Sub Mediterranean region of Slovenia.

Opilio transversalis ROEWER, 1956

Pišine, UL93, near the bridge over the Drnica stream, grass around a tree, 19.07.1999, LS, TN leg.: 3 mm, 1 f, 5 iuv. - 156/1999; 100 m E of stone plates in the Dragonja river bed, UL93, *Arundo*, grass, sieving, 20.07.1999, LS, TN leg.: 1 f - 190/1999; Lucija - Seča - Banjole, UL94, peach orchard, MS-N, TN leg., 07.09.1998: 1 f - 1782/1998; Strunjan, UL94, grass, 22.08.1999, MŠ, TN leg.: 1 f - 226/1999; Črniče, UL98, 17.08.2000, TN leg.: 1 m, 2 iuv. - 669/2000; drainage ditch S of Šempeter, UL98, 17.08.2000, TN leg.: 3 mm, 2 ff - 683/2000; 400 m NW Velike Žablje, VL07, *Rubus*, 17.08.2000, TN leg.: 1 m - 696/2000; Saksid, VL08, along the Vipava river, 17.08.2000, TN leg.: 1 m, 1 iuv. - 686/2000; Potok pri Dornberku, VL08, by the bridge, 17.08.2000, TN leg.: 1 f - 655/2000; Zarečica - Koseze - Velika Bukovica, VL34, 22.08.1998, forest edge meadow, 22.08.1998, LS, TN leg.: 1 m, 1 f - 1515/1998.

This is a common species in the Sub Mediterranean region of Slovenia.

Phalangium opilio LINNAEUS, 1758

Grič, 3 km E of Dragonja, UL93, 40 m, 11.10.1998, LS, TN leg.: 1 f - 1835/1998; Mlini, UL93, 10 m, 23.09.1998, LS, TN leg.: 1 f - 1825/1998; Nova vas, UL93, meadow, 260 m, 11.10.1998, LS, TN leg.: 1 m, 1 f - 1875/1998; Pišine, UL93, near the bridge over the Drnica stream, grass around a tree, 28.09.1999, LS, TN leg.: 2 mm, 1 f, 2 iuv. - 252/1999; grass near stone plates in the Dragonja river bed, UL93, below Abrami,

19.07.1999, LS, TN leg.: 1 iuv. - 144/1999; 100 m E of stone plates in the Dragonja river bed, UL93, *Arundo*, grass, sieving, 20.07.1999, LS, TN leg.: 1 m, 1 f, 1 f subad., 2 iuv. - 193/1999; Menik, Šmartno, UL89, grass, 09.08.2000, TN leg.: 1 f - 518/2000; Neblo, along the Kožbanjšček stream, UL89, 09.08.2000, TN leg.: 1 m - 515/2000; Korita na Krasu, UL97, sieving, forest edge, 17.08.2000, TN leg.: 1 f - 657/2000; drainage ditch S of Šempeter, UL98, 17.08.2000, TN leg.: 1 f - 681/2000; along the Lijak stream, UL98, Dombrava, 17.08.2000, TN leg.: 1 m - 675/2000; Marijino Celje, UM90, Lig, grass, 08.08.2000, TN leg.: 1 f - 542/2000; Gornje Nakovo, UM90, *Ostrya*, grass, sieving, 09.08.2000, TN leg.: 1 f - 550/2000; Sukavec, UM90, grass, 02.08.2000, TN leg.: 1 f - 303/2000; Ladra, UM92, 50 m away of the Soča river, forest edge, litter sieving, 25.09.1998, LS, TN leg.: 1 m, 1 f - 1812/1998; 500 m E of the road crossing Koper - Ljubljana - Ankaran, VL04, *Arundo*, *Clematis*, *Urtica*, 23.09.1998, LS, TN leg.: 1 m - 1785/1998; Čaven, VL08, Trnovski gozd, near the alpine cabin, 11.07.1995, TN leg.: 1 iuv. - 97/1997; Potok pri Dornberku, VL08, near a bridge, 17.08.2000, TN leg.: 1 m - 654/2000; Saksid, VL08, along the Vipava river, 17.08.2000, TN leg.: 1 m - 685/2000; Vipavski Križ - Cesta, VL18, cemetery, 17.08.2000, TN leg.: 1 m, 1 f - 678/2000; Zarečica - Koseze - Velika Bukovica, VL34, 22.08.1998, forest edge meadow, LS, TN leg., 22.08.1998: 1 m - 1516/1998.

This thermophilous species is common in the Sub Mediterranean region of Slovenia.

Platybunus bucephalus (C. L. KOCH, 1835)

1 km S of the Tolmin - Kobarid - Kamno road crossing, UM91, 200 m, sieving, 25.09.1998, LS, TN leg.: 11 iuv. - 1805/1998.

This montanous species occurs only in the margins of the Sub Mediterranean region of Slovenia.

SCLEROSOMATIDAE

Astrobonus helleri (AUSSERER, 1867)

300 m W of Proj, Brdice near Kožbana, UM80, along the Kožbanjšček stream, *S. aria*, *Fraxinus*, *Robinia*, *Corylus*, forest edge, sieving, 09.08.2000, TN leg.: 1 f - 526/2000; Avče, UM90, grass, 02.08.2000, TN leg.: 1 f - 296/2000; near the bridge at Doblar power station, UM90, *Fraxinus*, *Acer*, *Robinia*, litter sieving, 02.08.2000, TN leg.: 2 mm, 3 ff - 286/2000; Lepenka valley, UM90, Doblar, on a limestone wall, 25.09.1998, LS, TN leg.: 1 f - 1793/1998; 1 km S of the Tolmin - Kobarid - Kamno road crossing, UM91, 200 m, sieving, 25.09.1998, LS, TN leg.: 1 m - 1802/1998; Tublje near Hrpelje, VL15, *Carpinus*, *Tilia*, forest edge meadow, beneath stones, 20.07.1999, LS, TN leg.: 3 iuv. - 175/1999; Bač pri Martiriji, VL24, 24.10.1998, LS, TN leg.: 1 f - 1885/1998.

This montanous species is not common in the Sub Mediterranean region of Slovenia; it occurs only in the marginal regions of the territory.

Astrobunus laevipes (CANESTRINI, 1872)

Šmarje - Štanjel - Hrastje, VL07, grass, sieving, 17.08.2000, TN leg.: 1 m - 671/2000; Boršt, VL03, 02.04.1995, SP leg.: 1 m - 660/1998.

The species is sparsely distributed within the Sub Mediterranean region; it is more common at higher altitudes.

Gyas annulatus (OLIVIER, 1791)

200 m NWW Ježa (949 m), UM91, on the bridge, 08.08.2000, TN leg.: 1 m - 530/2000; Vrabče, VL17, Podnanos, 300 m, 10.03.1994, SB leg.: 1 pullus - 633/1998.

This mountain-alpine species occurs only marginally in the Sub Mediterranean region, and in some cold habitats near flowing water.

Leiobunum roseum C. L. KOCH, 1839

Lepenka valley, UM90, Doblar, on a limestone wall, 25.09.1998, LS, TN leg.: 1 m - 1792/1998; Sleme, UM91, 08.08.2000, TN leg.: 1 m, 1 iuv. - 531/2000.

This Southeastern-Alpine species occurs marginally in the Sub Mediterranean region in warm rocky habitats.

Leiobunum rupestre (HERBST, 1799)

Britof - Ukanje, UM80, rock walls, 09.08.2000, TN leg.: 1 m - 520/2000; 100 m SSW of Vogrinski, UM91, Srednje - Solarji, 08.08.2000, TN leg.: 1 m, 2 ff - 538/2000; Idrsko - Livek, UM92, on a cabin, 08.08.2000, TN leg.: 1 iuv. (f) - 528/2000.

The species is sparsely distributed within the parts of the Sub Mediterranean region that are marginal for its hygrophilous oligothermophilous character.

Nelima doriae (CANESTRINI, 1871)

Seča, Ribič, UL83, 21.08.1999, grass, MŠ, TN leg.: 1 f, 1 iuv. - 228/1999; Nova vas, 260 m, UL93, meadow, 11.10.1998, LS, TN leg.: 1m, 1 f, cf. 2 iuv. - 1860/1998; Seča, UL93, *Arundo*, 1-3 m, 10.10.1998, LS, TN leg.: 3 mm - 1846/1998; Sečoveljske soline, UL93, 100 m W of Droga, 1-2 m, 10.10.1998, LS, TN leg.: 2 mm, 1 f - 1872/1998.

N. doriae is a Mediterranean species, common in the region's warm and moderately humid places.

Nelima narcisi NOVAK & SLANA, 2003

100 m E of stone plates in the Dragonja river bed,

UL93, *Arundo*, grass, sieving, 20.07.1999, LS, TN leg.: 4 iuv. - 195/1999; 1 km E of Dragonja, UL93, grass, 40 m, 11.10.1998: 1 iuv. - 1839/1998; 2 km E of Dragonja, UL93, 40 m, grass, 11.10.1998: 1 iuv. - 1863/1998; Nova vas, 260 m, UL93, meadow, LS, TN leg., 11.10.1998: 3 iuv. - 1861/1998; 1 km W of Novi Brič (312 m), UL93, the road crossing for Puče, 110 m, 11.10.1998, LS, TN leg.: 1 f - 1843/1998; 500 m E of Padna, UL93, beneath stones, 220 m, 23.09.1998, LS, TN leg.: 3 mm, 2 ff, 5 iuv. - 1877/1998; ca. 300 m SE of St. Onofrij, Parecag, UL93, 02.09.2000, LS, TN leg.: 6 mm - 701/2000; *ibid.*, under stones, 10.10.1998: 3 mm, 1 f, 1 iuv. - 1837/1998; Seča, UL93, by the road; *Arundo*, sieving, 1-3 m, 10.10.1998, LS, TN leg.: 4 mm - 1849/1998; *ibid.*, *Ostrya*, *Quercus*, sieving, brushwood, 21.08.1999, MŠ, TN leg.: 1 iuv. - 235/1999; Župančiči - Fiejeroga, VL03, beneath stones, 230 m, 10.11.1998, LS, TN leg.: 2 ff, 1 iuv. - 1859/1998.

N. narcisi is a Northern-Adriatic species, common in the region's warm and moderately humid places. At Debeli rtič, specimens are not as small as described in Novak & Slana (2003; Martens *in lit.*); it is possible that very small individuals occur only in extremely dry, sunward places, where they were collected for the type series.

Nelima sempronii SZALAY, 1951

Grass near stone plates in the Dragonja river bed, UL93, below Abrami, 19.07.1999, LS, TN leg.: 1 f - 145/1999; Fenendra, UL93, Draga, grass, 22.08.1999, MŠ, TN leg.: 1 m - 224/1999; Kaštinjol, UL93, grass, 11.10.1998, LS, TN leg.: 1 m, 3 ff - 1870/1998; Korte, UL93, 350 m NNW of Parecag, 60 m, *Ostryetum*, 23.09.1998, LS, TN leg.: 1 m, 2 ff - 1822/1998; Lucija - Seča - Debernardo, UL93, *Arundo*, beneath stones, 22.09.1998, LS, TN leg.: 8 mm, 4 ff - 1819/1998; the bridge over the Medjanščica stream, UL93, Padna - Korte, 21.08.1999, TN leg.: 1 m, 2 ff - 237/1999; Mlini - Dragonja, UL93, grass along the Dragonja river, 21.08.1999, TN leg.: 4 m - 234/1999; 900 m SSE of Paderno (Seča), UL93, 5 m, near a bridge, 10.10.1998, LS, TN leg.: 2 mm - 1854/1998; Pišine, UL93, near the bridge over the Drnica stream, grass around a tree, 19.07.1999, LS, TN leg.: 4 iuv. - 157/1999; *ibid.*, 28.09.1999, LS, TN leg.: 2 mm - 251/1999; Lucija - Seča - Banjole, under the bridge, 07.09.1998, UL94, MSN, TN leg.: 2 ff - 1781/1998; drainage ditch S of Šempeter, UL98, 17.08.2000, TN leg.: 2 mm, 2 ff - 682/2000; Ajševica, UL99, the bridge over the Lijak stream, 17.08.2000, TN leg.: 1 f - 661/2000; 350 m NE of Grgarske Ravne, UL99, *Tilia*, *Corylus*, *Fraxinus*, sieving, 02.08.2000, TN leg.: 1 iuv. - 318/2000; Avče, UM90, grass, 02.08.2000, TN leg.: 1 iuv. - 295/2000; Marija Snežna, UM90, *Luzula silvestris*, grass, sieving, 02.08.2000, TN leg.: 1 m, 2 ff, 3 iuv. - 289/2000; Marijino Celje, UM90, Lig, grass, 08.08.

2000, TN leg.: 1 iuv. - 543/2000; Sukavec, UM90, grass, 02.08.2000, TN leg.: 1 f, 11 iuv. - 302/2000; 250 m SE of Zabrdó (Grgar), UL99, *Quercus*, *Fraxinus*, sieving, 02.08.2000, TN leg.: 1 iuv. - 306/2000; Velendol, UM80, *Tilia*, beneath stones, sieving, 09.08.2000, TN leg.: 1 m - 516/2000; Ladra, UM92, 50 m from the Soča river, forest edge, litter sieving, LS, TN leg., 25.09.1998: 4 mm, 2 ff - 1813/1998; 300 m W Miši, VL04, Dekani, near the bridge over the Rižana river, 20 m, 11.10.1998, LS, TN leg.: 4 mm, 1 f - 1833/1998; Bača pri Modreju, VM01, *Ostrya*, grass, sieving, 09.08.2000, TN leg.: 3 mm, 3 ff, 1 iuv. - 556/2000; 500 m E of the Koper – Ljubljana – Ankaran road crossing, VL04, *Arundo*, *Clematis*, *Urtica*, 23.09.1998, LS, TN leg.: 4 mm, 3 ff - 1786/1998; Šmarje - Štanjel - Hrastje, VL07, grass, sieving, 17.08.2000, TN leg.: 2 ff - 670/2000; Potok near Dornberk, VL08, near bridge, 17.08.2000, TN leg.: 1 f - 656/2000; the road crossing for Brezovica, VL14, 80 m, along the Rižana river, 23.09.1998, LS, TN leg.: 2 mm - 1820/1998; Ajdovščina - Vipavski Križ, VL18, near the influx of the Hubelj river, brushwood, 17.08.2000, TN leg.: 1 f - 663/2000; *ibid.*: 1 m, 4 ff - 664/2000; Bač pri Materiji, VL24, 24.10.1998, LS, TN leg.: 1 f - 1884/1998; Rečica, VL34, Ilirska Bistrica, near the bridge over the Reka river, 400 m, *Urtica*, *Rubus*, 22.08.1998, LS, TN leg.: 2 mm, 3 ff - 1512/1998; Zarečica - Koseze - Velika Bukovica, VL34, 22.08.1998, forest edge meadow, 22.08.1998, LS, TN leg.: 3 mm, 5 ff - 1519/1998.

This hygrophilous species is locally distributed in the Sub Mediterranean region, occurring in humid, mostly shady places along flowing water.

DISCUSSION

To date, 34 species and one subspecies have been recorded in the Sub Mediterranean territory of Slovenia. Additionally, more troguli species belonging to the groups of *T. nepaeformis* and *T. tricarinatus* are expected. The juvenile *Trogulus* from Strunjan in the Jochen Martens Collection (JM 1617), presumably belonging to *T. coriziformis* C. L. KOCH, 1839, was found to be *T. tingiformis* (Schönhofer *in lit.*). Not all of the recorded species are common in the region. According to their distribution, the following 16 species, plus at least four troguli species of the groups *T. nepaeformis* and *T. tricarinatus*, are to be considered as characteristic of the territory: *Scotolemon doriae*, *Carinostoma carinatum*, *Nemastoma bidentatum sparsum*, *N. dentigerum*, *Mitostoma chrysomelas*, *Trogulus coriziformis*, *T. gr. nepaeformis*, *T. gr. tricarinatus*, *Lacinius horridus*, *Metaphalangium cirtanum*, *Odiellus spinosus*, *Opilio dinari-*

cus, *O. saxatilis*, *O. transversalis*, *Phalangium opilio*, *Nelima doriae*, *N. narcisi* and *N. sempronii*.

In the region, some further species can be expected locally, such as *Anelasmoecephalus hadzii* MARTENS, 1978, *Trogulus closanicus* AVRAM, 1971, and *Holoscotolemon unicolor* ROEWER, 1915, at higher altitudes, since they are known in adjacent regions. For the same reasons, perhaps locally an *Ischyropsalis* species would be expected, such as *Ischyropsalis hellwigii hellwigii* (PANZER, 1794), in higher cold places, and *I. muellneri* HAMANN, 1898, in caves in the very northern part of the region. *Platybunus pinetorum* (C. L. KOCH, 1839) has not been found in Slovenia; perhaps it inhabits some isolated, wet habitat in the very northern part of the region.

Opilio canestrinii THORELL, 1876, has been expected, but not yet found in bigger towns, like Koper. This species is expanding all over Central Europe and will sooner or later also appear in this region. Although it seems no longer very probable, *Astrobunus dinaricus* ROEWER, 1915, would still be expected to occur in the region, as it has been described from Opatija (Croatia). The discovery of some further, laniatorid and/or nemastomatid subterranean opilionid species in the region cannot be excluded, but because of the sparse limestone territory and very limited accessibility of the hypogean habitats, the chances are relatively poor. Such discoveries could be expected in the future, if a convenient sampling method for epikarstic biota is introduced.

ACKNOWLEDGEMENTS

I am very grateful to all who collected the opilionid material, contributing in this way much to this study. Many thanks to James Cokendolpher who reminded me of some papers, dealing with the opilionids in Slovenia that had been overlooked in the review of harvestmen in Slovenia (Novak & Gruber, 2000). I am indebted to Jochen Martens and Axel Schönhofer for the information about the *Trogulus* cf. *coriziformis*, to Tomi Trilar for the information about the *Histicostoma dentipalpe* specimen found attached on an *Apodemus*, to Christian Komposch and Dušan Devetak for critical reading of the manuscript, and to Michelle Gadpaille for help in improving the language. The study was partly supported by the Slovene Ministry of High Education, Science and Technology within the Biodiversity research programme (P1-0078).

Abbreviations used: BB - Barbara Bertoncelj, SB - Savo Brelih, TN - Tone Novak, BO - Boštjan Ogrizek, SP - Slavko Polak, LS - Ljuba Slana Novak, MSN - Maja Slana Novak, MŠ - Mojmir Štangelj, TT - Tomi Trilar.

SUHE JUŽINE (ARACHNIDA: OPILIONES) SUBMEDITERANSKE REGIJE SLOVENIJE – II

Tone NOVAK

Univerza v Mariboru, Pedagoška fakulteta, Oddelek za biologijo, SI-2000 Maribor, Koroška 160

E-mail: tone.novak@uni-mb.si

POVZETEK

V članku so predstavljene nove najdbe suhih južin v submediteranski regiji Slovenije ter dodani komentarji k nekaterim aktualnim problemom v zvezi z določenimi vrstami. Predvidoma smo našli vse v regiji živeče vrste, razen morebitne neodkrite troglobiontske vrste. V regiji je bilo brez upoštevanja ploščkov iz skupin *Trogulus* gr. *nepaeformis* in *T. gr. tricarinatus*, kjer je pričakovanih več vrst, skupno najdenih 34 vrst in ena podvrsta. Za regijo je značilnih kakih 20 vrst suhih južin, medtem ko druge živijo na obrobju habitatov, ki mejijo na druge zoogeografske regije.

Ključne besede: pajkovci, suhe južine, Slovenija, submediteran

REFERENCES

- Blick, T. & Ch. Komposch (2004):** Checkliste der Weberknechte Mittel- und Nordeuropas. Checklist of the harvestmen of Central and Northern Europa (Arachnida: Opiliones). Version 27. Dec 2004. http://www.AraGes.de/checklist.html#2004_Opiliones
- Komposch, Ch. (2000):** *Trogulus falcipenis*, spec. nov., ein neuer Brettkanker aus den Alpen und dem Dinarischen Gebirge. Spixiana, 23(1), 83–96.
- Novak, T. & J. Gruber (2000):** Remarks on published data on harvestmen (Arachnida: Opiliones) from Slovenia. Annales Ser. Hist. Nat., 10(2), 281–308.
- Novak, T., J. Gruber & L. Slana (1995):** A contribution to the knowledge of the harvestmen (Opiliones) from the Sub-Mediterranean region of Slovenia. Annales Ser. Hist. Nat., 5, 181–192.
- Novak, T. & L. Slana (2003):** *Nelima narcisi* n. sp., a dwarf member of the genus from the North-Eastern Adriatic coast (Arachnida, Opiliones, Phalangidae s. l.). Fragm. Entomol., 35(1), 1–11.
- Schönhöfer, A. (2004):** Die europäischen Brettkanker der Gattung *Trogulus* Latreille (Opiliones: Trogulidae), Molekulare Phylogenie und Artgrenzen. B.Sc. Thesis. Univ. J. Gutenberg, Mainz, 96 pp.
- Lipovšek Delakorda, S., T. Novak, F. Janžekovič, L. Senčič & M. A. Pabst (2004):** A contribution to the functional morphology of the midgut gland in phalangiid harvestmen *Gyas annulatus* and *Gyas titanus* during their life cycle. Tissue & Cell, 36, 275–282.
- Lipovšek, S., I. Letofsky-Pabst, F. Hofer & M. A. Pabst (2002):** Seasonal and age-dependent changes of the structure and chemical composition of spherites in the midgut gland of the harvestmen *Gyas annulatus* (Opiliones). Micron, 33, 647–654.
- Lipovšek, S., I. Pabst, T. Novak & M. A. Pabst (2000):** Spherites in the midgut of *Gyas annulatus* show seasonal changes. Proc. 12th European Congress Electron Microscopy, Brno, Czechoslovakia. Soc. Electron Microscopy, I B415–B416.
- Novak, T. (2004):** An overview of harvestmen (Arachnida: Opiliones) in Croatia. Nat. Croat., 13(3), 231–296.
- Novak, T. & V. Kuštor (1983):** On *Troglophilus* (Raphidophoridae, Saltatoria) from north Slovenia. Mém. Biospéol., 10, 127–137.
- Novak, T., S. Lipovšek Delakorda, L. Senčič, M. A. Pabst & F. Janžekovič (2004):** Adaptations in phalangiid harvestmen *Gyas annulatus* and *G. titanus* to their preferred water current adjacent habitats. Acta Oecol., 26, 45–53.
- Novak, T., J. Sambol & F. Janžekovič (2004):** Faunal dynamics in the Železna jama cave. Acta Carsol., 33(2), 249–267; <http://www.zrc-sazu.si/izrk/carsolog.htm>.
- Novak, T., L. Slana, N. Červek, M. Mlakar, N. Žmaher & J. Gruber (2002):** Harvestmen (Opiliones) in human settlements of Slovenia. Acta Entomol. Slov., 10(2), 131–154.

SUPPLEMENT

Literature on opilionids in Slovenia, supplementary to the review in Novak & Gruber (2000):

Novak, T., S. Lipovšek & L. Slana (2000): Biogeographical remarks on *Gyas titanus* Simon, 1879 (Opiliones, Phalangidae) in the Balkans. Nat. Croat., 9(3), 189–194.

Rafalski, J. (1958): A description of *Siro carpaticus* sp. n. with remarks on the morphology and systematics of the Cyphophthalmi (Opiliones). Acta Zool. Cracov., 2, 521–556.

Sambol, J. & T. Novak: Favna Železne jame. V: Stražar, I. (ur.): 40 let Društva za raziskovanje jam Simon Robič Domžale: 1961–2001. Domžale.

Sket, B. (1980): Jamska favna notranjskega trikotnika (Cerknica – Postojna – Planina), njena ogroženost in naravovarstveni pomen. Varstvo narave, 12, 45–59.

Tarman, K., 2003: Pajkovci – Arachnida. V: Sket, B., M. Gogala & V. Kuštor (ur.): Živalstvo Slovenije. Tehniška založba Slovenije, Ljubljana, str. 161–185.

izvirni znanstveni članek
prejeto: 2005-03-17

UDK 574.4:598.2(497.4-14)

TRAVNIŠKE ORNITOCENOZE DNEVNO AKTIVNIH GNEZDILCEV V JZ SLOVENIJI

Davorin TOME

Nacionalni inštitut za biologijo, SI-1000 Ljubljana, Večna pot 111

E-mail: davorin.tome@nib.si

IZVLEČEK

*Z metodo linijskega transeкта sem popisoval dnevno aktivne ptice na nekaterih travnikih v JZ Sloveniji. Največje gostote sta dosegala poljski škrjanec (*Alauda arvensis*; do 97 parov/km²) in veliki strnad (*Miliaria calandra*; do 49 parov/km²). Njuna gostota se je spreminjala obratno sorazmerno. Poljskih škrjancev je bilo več na nezaraščenih travnikih, velikih strnadov pa na površinah, zaraščenih z grmovjem. Spremembe v populacijski gostoti obeh vrst so verjetno najboljši kazalec začetka procesa zaraščanja na kraških travnikih v Sloveniji. Travnik pri Kastelcu se je od drugih najbolj razlikoval, predvsem zaradi velikih gostot poljskega in hribskega škrjanca (*Lullula arborea*) in ker se je le na tem travniku pojavljala rjava cipa (*Anthus campestris*).*

Ključne besede: travniške ptice, gnezdilci, zaraščanje, Kras, JV Slovenija

ORNITOCENOSI DI PASCOLO DI NIDIFICATORI DIURNI IN SLOVENIA SUD-OCCIDENTALE

SINTESI

*Con il metodo del transetto lineare l'autore ha steso l'inventario degli uccelli diurni di alcuni pascoli della Slovenia sud-occidentale. I maggiori valori di densità sono stati raggiunti dall'allodola (*Alauda arvensis*; fino a 97 coppie/km²) e dallo strillozzo (*Miliaria calandra*; fino a 49 coppie/km²). La densità di queste due specie era inversamente proporzionata. Le allodole erano più numerose su pascoli non rigogliosi, gli strillozzi invece su superfici con folti arbusti. Le variazioni nella densità di popolazione di entrambe le specie indicano l'inizio della crescita rigogliosa dei pascoli carsici in Slovenia. La densità massima di allodole e tottaville è stata registrata nel pascolo vicino a Kastelec, dove è stata segnalata anche la presenza del calandro (*Anthus campestris*).*

Parole chiave: uccelli di pascolo, nidificatori, vegetazione rigogliosa, Carso, Slovenia sud-occidentale

UVOD

Kljub precejšnji orientiranosti slovenskih opazovalcev ptic proti JZ Sloveniji (Tome, 2000) je sistematičnih pregledov ptic tega predela razmeroma malo. Izjema so seveda obmorski ornitološki vrtovi, Sečoveljske soline (npr. Škornik *et al.*, 1990; Makovec *et al.*, 1998), Škocjanski zatok (npr. Geister, 1987; Škornik *et al.*, 1990), reka Dragonja (Sovinc, 1998; Gregori, 2002). O združbah ptic nad Kraškim robom pa je razen kratkih poročil o opazovanju posameznih vrst prispevkov malo, kljub velikim spremembam, ki se tu dogajajo zaradi zaraščanja. Izjema sta sistematična popisa ptic Petrinjskega krasa in Goliča (Geister, 1999, 2002) in pregled pojavljanja sov in ujed v slovenski Istri (Lipej & Gjerkeš, 1994).

V tem delu poročam o združbi dnevno aktivnih gnezdilcev na nekaterih travniških lokacijah na krasu, s poudarkom na razlikah med nezaraščenimi in z grmovjem delno zaraščenimi območji. Podatke primerjam s sestavo ptic na travnikih v dolini Pivke, na nekraški podlagi.

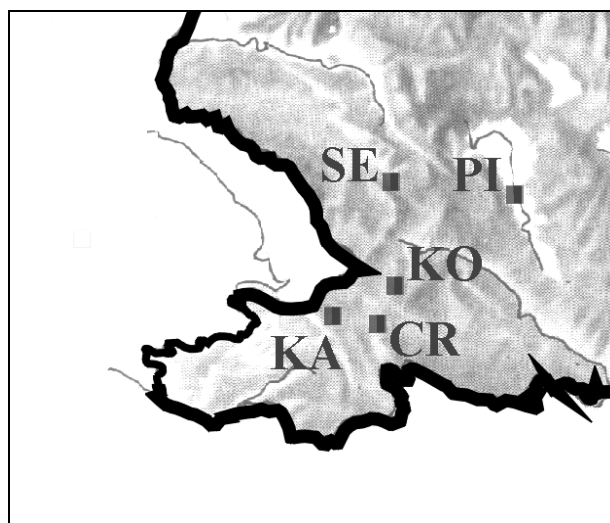
MATERIAL IN METODE

Opis območja

Ptice sem popisoval na travnikih štirih območjih: v dolini Pivke med naseljema Selce in Trnje (transekti PI1, PI2), na Senožetskem podolju zahodno od Senožech (transekti SE1, SE2, SE3), na travnikih med Kozino in naseljem Slope (transekti KO1, KO2), na Velikem krasu vzhodno od Črnotič (transekti CR1, CR2, CR3), na spodnjem krasu pri Kastelcu (transekt KA1) (Tab. 1, Sl. 1). Pivška transekti sta po novi regionalizaciji Slovenije na Pivškem podolju (Dinarski svet), drugi so na krasu (Sredozemski svet; Perko & Orožen Adamič, 1998). Po

mojem predlogu (Tome, 1998) sodijo vsa območja razen Pivškega v submediteransko ornitogeografsko regijo.

Vsi transekti so bili na nadmorski višini med 300 in 600 m. Nekaj jih je bilo speljanih po bolj ali manj kamnitih travnikih, ki jih kosijo pozno, morda ne vsako leto in imajo le posamezna listopadna ali zimzelena grmovja ter drevesa. V delu jih imenujem kraški travniki. Travnike v Pivškem podolju kosijo redno vsako leto. V letih 1999 in 2000 so se košnje na njih lotili v začetku junija, a je bilo v času popisa pokošene manj kot 10 % površine. V tem delu jih imenujem intenzivni travniki. Na nekaterih travnikih je bila večja površina izločena iz



Sl. 1: Položaj popisanih travnikov v JZ Sloveniji. Kratice ustrezajo oznakam transektov v Tabeli 1.

Fig. 1: The position of mapped grasslands in SW Slovenia, with the abbreviations corresponding to the transect denotations in Table 1.

Tab. 1: Popisni transekti – kratica, dolžina, grob opis in datumi popisa (* polovica transeкта je intenzivno oskrbovan travnik, druga polovica se deloma zarašča z grmovjem).

Tab. 1: The mapped transects – abbreviation, length, rough description, and date of mapping (* half of the transect is intensively farmed meadow, while the other half is partially overgrown with bushes).

območje	transekt	dolžina (m)	opis	datum popisa
Pivško	PI1	3500	travnik v zaraščanju*	26.4. in 1.6.2000
Pivško	PI2	3300	travnik	26.4. in 1.6.2000
Senožet	SE1	1000	kraški travnik	30.4. in 6.6.1999
Senožet	SE2	1200	kraški travnik	30.4. in 6.6.1999
Senožet	SE3	1000	travnik v zaraščanju	30.4. in 6.6.1999
Kozina	KO1	750	travnik v zaraščanju	30.4. in 6.6.1999
Kozina	KO2	1400	travnik v zaraščanju	30.4. in 6.6.1999
Črnotič	CR1	1500	kraški travnik	1.5. in 13.6.1999
Črnotič	CR2	1500	travnik v zaraščanju	1.5. in 13.6.1999
Črnotič	CR3	1200	kraški travnik	1.5. in 13.6.1999
Kastelec	KA1	1400	kraški travnik	1.5. in 13.6.1999

košnje že pred časom in tako zaraščena z listopadnim grmovjem in/ali nizkim drevjem (po oceni je bilo v okolici transektu zaraščene med 20 in 40 % površine). Takšne travnike v tem delu imenujem travniki v zaraščanju. Večina travnikov v zaraščanju je bila na krasu, travnik ob transektu PI1 pa v Pivški dolini, a v zaraščanju je bila le polovica površine, druga polovica je bila redno košena.

Metoda

Ptice sem popisoval z metodo transektu. Popisoval sem od jutranjega svita do 10. ure. Štel sem v dveh pasovih, do in nad 50 m. Vsak transekt je bil popisani dvakrat (Tab. 1). Pri analizi sem za vsako vrsto posebej upošteval večjo od obeh dobljenih vrednosti. Upošteval sem le vrste, ki po metodologiji ornitološkega atlasa sodijo v gnezditveno kategorijo B, C ali D (Geister, 1995). Iz podatkov sem izračunal relativno gostoto ptic ob predpostavki, da zaznavnost vrst pravokotno od transektu upada linearno (Järvinen & Väisänen, 1975). Napaka ocene pri tej metodi se giblje med okoli ± 20 %, če je bilo na transektu odkritih 10 osebkov, in okoli ± 40 %, če sta bila odkrita dva. Vsem vrstam, ki so bile v posameznem

transektu zabeležene le v zunanjem pasu (izračun gostote v tem primeru ni mogoč), sem pri nadaljnji obdelavi določil arbitrarno gostoto 1 par na km², da sem jih s tem ločil od vrst, ki se ob transektu niso pojavile.

Konstantnost pojavljanja sem ugotavljal z deležem transektov, v katerih je bila vrsta odkrita. Vrste z gostoto nad 10 parov/km² in konstantnostjo nad 75 % opredeljujem kot pogoste vrste gnezdilcev na travnikih JZ Slovenije.

Pri ugotavljanju podobnosti v sestavi ornitofavne posameznih popisnih območij z metodo kopičenja (endogram) sem med podatki računal Evklidove razdalje, gručice pa združeval po metodi UPGMA.

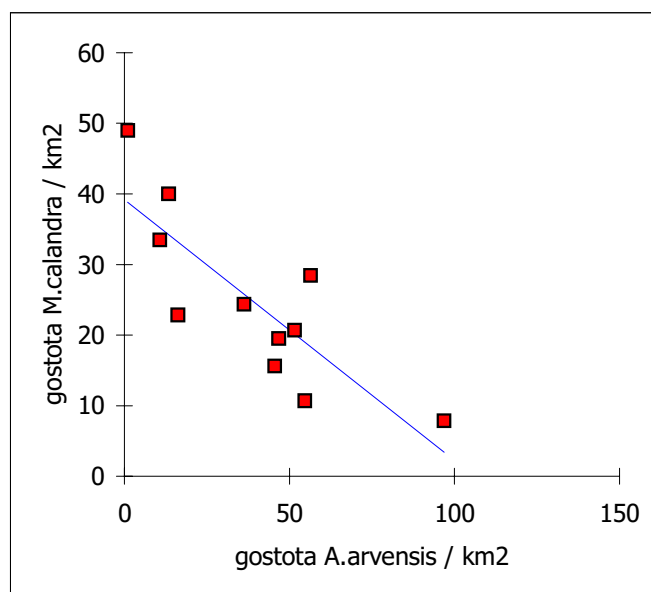
REZULTATI IN RAZPRAVA

Na območju sem registriral 26 gnezdilcev, med katerimi so se kosec (*Crex crex*), smrdokavra (*Upupa epops*), vijeglavka (*Jynx torquilla*), drevesna cipa (*Anthus trivialis*), sivi muhar (*Muscicapa striata*), kobilar (*Oriolus oriolus*), grilček (*Serinus serinus*), lišček (*Carduelis carduelis*) in plotni strnad (*Emberiza cirrus*) pojavljali le v zunanjih pasovih transektov, tako da jih v nadaljnji analizi ne obravnavam.

Tab. 2: Gostota vrst ptic na km², ki so bile vsaj v enem transektu zabeležene v notranjem pasu. Legenda: + = vrsta je bila v določenem transektu zabeležena samo v zunanjem pasu; – = vrsta ob transektu ni bila odkrita; tot = relativna gostota vrste, izračunana za vse transekte (skupna dolžina transektov = 17,8 km); ko = konstantnost pojavljanja vrste (v koliko % od 11 transektov se je vrsta pojavljala v notranjem pasu); N = število osebkov, odkritih v zunanjem in notranjem pasu vseh transektov.

Tab. 2: Density of birds per km², which were at least in one transect recorded in the inner belt. Legend: + = in a certain transect the species was recorded only in the outer belt; – = the species was not recorded along the transect; tot = species' relative density, calculated for all transects (total length of transects = 17.8 km); ko = a constancy of the species' occurrence (in how many % of the 11 transects the species occurred in the inner belt); N = No. of individuals recorded in the outer and inner belts of all transects.

vrsta/transekt	PI1	PI2	SE1	SE2	SE3	CR1	CR2	CR3	KA1	KO1	KO2	tot	ko	N
<i>Coturnix coturnix</i>	3,3	3,2	-	-	11,7	+	-	-	-	-	-	1,9	27	9
<i>Lullula arborea</i>	-	-	+	+	-	-	+	+	8,4	+	-	0,6	9	9
<i>Alauda arvensis</i>	16,2	51,6	54,7	56,4	10,7	45,6	13,3	46,7	96,8	-	36,2	37,1	91	123
<i>Anthus campestris</i>	-	-	-	-	-	-	-	-	28,6	-	-	2,2	9	2
<i>Luscinia megarhynchos</i>	-	-	-	-	-	-	7,8	-	-	-	+	0,6	9	3
<i>Saxicola rubetra</i>	18,6	28,1	-	-	-	-	-	-	-	-	-	8,7	18	24
<i>Saxicola torquata</i>	-	-	25,4	-	-	-	13,3	-	-	-	-	2,2	18	4
<i>Turdus merula</i>	6,7	3,3	+	+	25,4	7,8	+	-	8,4	33,8	7,7	6,2	63	29
<i>Acrocephalus palustris</i>	11,4	7,7	-	-	-	-	-	-	-	-	-	3,1	18	5
<i>Sylvia nisia</i>	5,7	-	-	-	-	-	-	-	-	-	-	1,1	9	1
<i>Sylvia communis</i>	38,6	+	20,0	16,7	+	-	-	16,7	28,6	-	-	10,8	45	22
<i>Lanius collurio</i>	3,1	3,6	20,0	9,8	-	-	26,7	-	18,1	33,8	18,1	9,1	73	21
<i>Chloris chloris</i>	+	-	-	16,7	-	-	+	-	8,4	26,7	+	1,9	27	7
<i>Carduelis cannabina</i>	5,7	6,1	-	-	-	-	-	-	14,3	-	-	3,4	27	3
<i>Emberiza citrinella</i>	15,8	-	-	+	+	7,8	+	-	-	+	+	3,2	18	13
<i>Emberiza hortulana</i>	-	-	-	-	-	+	+	21,1	-	-	-	1,3	9	5
<i>Miliaria calandra</i>	22,9	20,7	10,7	28,5	33,5	15,6	40,0	19,5	7,9	49,0	24,4	23,2	100	81



Sl. 2: Korelacija med relativno gostoto na km² poljskega škrjanca (*Alauda arvensis*) in velikega strnada (*Miliaria calandra*) na preučevanih travnikih JZ Slovenije ($R_{\text{Pearson}} = -0,82, p=0,002$).

Fig. 2: Correlation between the relative density per km² of Skylark (*Alauda arvensis*) and Corn Bunting (*Miliaria calandra*) in the studies grasslands of SW Slovenia ($R_{\text{Pearson}} = -0.82, p=0.002$).

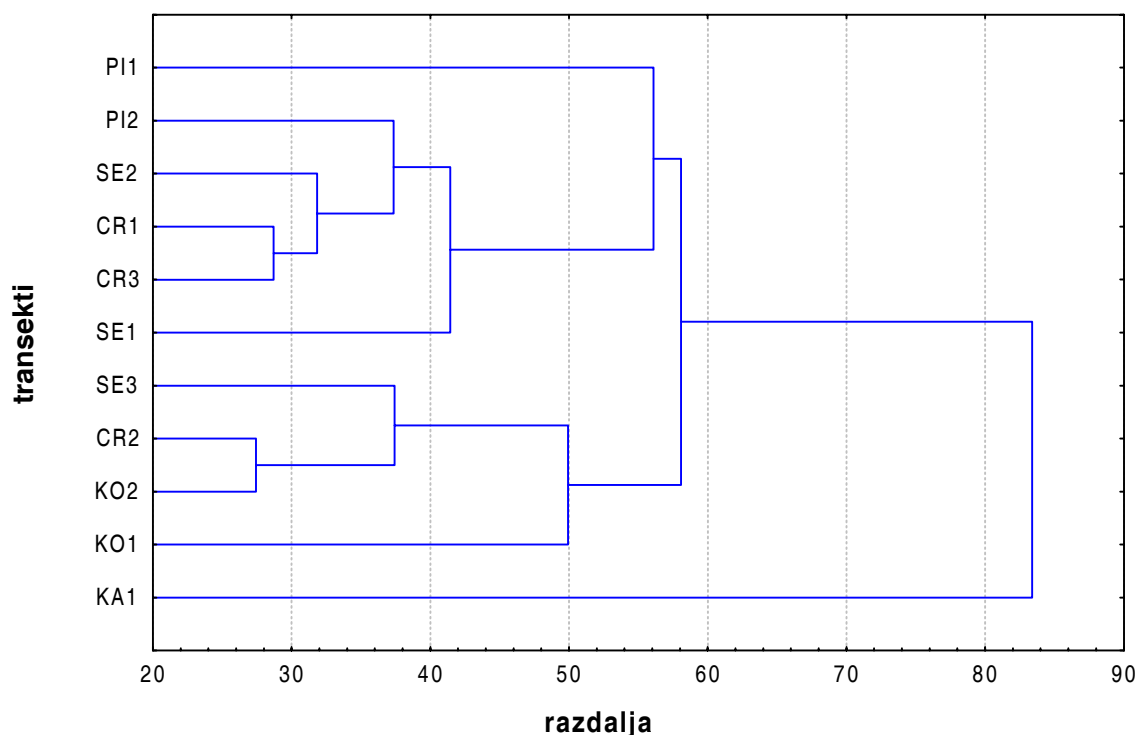
Največje gnezditvene gostote sta dosegla poljski škrjanec (*Alauda arvensis*; od 13 do 97 parov na km² v zasedenih kvadratih) in veliki strnad (*Miliaria calandra* od 9 do 49 parov na km²). Pri obeh vrstah je bila ugotovljena tudi velika konstantnost pojavljanja. Veliki strnad se je pojavljal ob vseh transektih, poljskega škrjanca nisem zabeležil le ob enem (Tab. 2). Vrsti zato označujem kot pogosta gnezdilca travnikov JZ Slovenije. Njuni gostoti sta se spreminjali značilno obratno sorazmerno (Sl. 2).

Repaljščica (*Saxicola rubetra*), kos (*Turdus merula*), rjava penica (*Sylvia communis*) in rjavi srakoper (*Lanius collurio*) so dosegli gostote nad 10 parov na km², a le na transektih v posameznih tipih travnikov. Konstantnost pri teh vrstah je imela srednje vrednosti. Repaljščica je bila odkrita le na travnikih v Pivški dolini. Med vsemi raziskovanimi območji so to edini travniki, ki so na podlagi iz rečnih nanosov in imajo poplavni značaj (Perko & Orožen Adamič, 1998). Na travnikih kraškega tipa repaljščic ni bilo. Ali jim ne ustreza struktura travne ruše ali pa morda način gospodarjenja, kar ugotavlja že Geister (1995).

V analizi podobnosti ornitofavne se je večina transektov združila v dve skupini (Sl. 3). V skupino t.i. kraških travnikov (SE1, SE2, CR1, CR3) in skupino zaraščajočih se travnikov (SE3, CR2, KO1, KO2). Okolica transektu PI2 v Pivški dolini je bila na podlagi kmetijskih dejavnosti a priori določena kot intenzivna, a travnik se je na podlagi analize ornitocenoze uvrstil med kraške travnike. To kaže, da je gospodarjenje na njem še vedno

dovolj ekstenzivno, da je za ptice zanimiv. Tudi zaraščajoči se travnik v Pivški dolini (ob transektu PI1) je metoda kopičenja uvrstila med kraške travnike, a razlika v točki ločitve s travniki v zaraščanju je bila zelo majhna. To je verjetno posledica heterogenosti območja, saj ga je polovica v obliki travnika, druga pa ima velik del površine preraščene z grmovjem. Med vsemi se je najbolj razlikoval travnik ob naselju Kastelec (KA1), predvsem zaradi velike gostote poljskih in hribskih škrjancev (*Lullula arborea*), majhne gostote velikih strnadov in ker je bil edini transekt z rjavo cipo (*Anthus campestris* – dva pojoča samca). To izjemno območje je bilo ob graditvi odseka primorske avtoceste uničeno.

Največje razlike v sestavi ornitofavne travnikov, ki so bili v analizi uvrščeni v skupino kraških travnikov (izločil sem oba travnika iz Pivške doline, ki ležita na drugačni podlagi), in tistimi, ki so bili uvrščeni v skupino travnikov v zaraščanju, so bile v gostoti poljskega škrjanca, rjave penice, rjavega srakoperja in velikega strnada. Škrjanec in penica sta dosegla značilno večje gostote na kraških travnikih kot na travnikih v zaraščanju (Hi-kvadrat 18,8 in 9,8; $p < 0,001$; $ps=2$). Srakoper in strnad sta imela značilno večje populacije na zaraščajočih se kot kraških travnikih (Hi-kvadrat = 28,4 in 6,0; $p < 0,001$ in $p=0,01$; $ps = 2$). Ocenjujem, da je prva faza zaraščanja kraških travnikov pri nas najbolj opazna prav v zmanjšanju gostote poljskih škrjancev in povečanju gostote velikih strnadov. Spremljanje zaraščanja z drugimi vrstami, vključno s penico in srakoperjem, je manj opazno, saj vrste v okolju niso tako pogoste.



Sl. 3: Podobnost med ornitocenozo posameznih transektov. Podobnost je izračunana iz podatkov relativne gostote z Evklidovo razdaljo; skupine so združene po metodi UPGMA (za kratice transektov glej Tab. 1).

Fig. 3: Similarity between the ornithocenosis of separate transects, established from data on relative density with Euclid's distance; the groups are merged per UPGMA method (for transect abbreviations see Tab. 1).

GRASSLAND ORNITHOCENOSES OF DAILY ACTIVE BREEDING BIRDS IN SW SLOVENIA

Davorin TOME

National Institute of Biology, SI-1000 Ljubljana, Večna pot 111

E-mail: davorin.tome@nib.si

SUMMARY

Daily active birds were mapped with line transect method in some meadows of SW Slovenia. The highest densities were recorded for Skylark (*Alauda arvensis*; up to 97 pairs/km²) and Corn Bunting (*Miliaria calandra*; up to 49 pairs/km²). Their density changed inversely proportionally. Skylarks were more abundant in the meadows not overgrown with herbage, while Corn Buntings were more numerous in the areas overgrown with bushes. The changes in the population density of both species are probably the best indicator of the beginning of the overgrowing process in karst meadows of Slovenia. The meadow at Kastelec differed from the others to the greatest extent, primarily due to the high densities of Skylark and Woodlark (*Lullula arborea*) and owing to the fact that Tawny Pipit (*Anthus campestris*) was present only in this particular meadow.

Key words: grassland birds, breeders, overgrowing, Karst, SW Slovenia

LITERATURA

- Geister, I. (1987):** Prezimovanje in prelet ptic v Škotskem zalivu in Zalivu Polje pri Kopru. Varst. Narave, 13, 59–68.
- Geister, I. (1995):** Ornitološki atlas Slovenije. DZS, Ljubljana, 287 str.
- Geister, I. (1999):** Gnezdilke popogoriščnega habitata na Petrinjskem Krasu. Annales, Ser. hist. nat., 9(2), 299–302.
- Geister, I. (2002):** Popis gnezdečih ptic na planoti med Goličem, Lipnikom in Kavčičem (Čičarija, Slovenija). Annales, Ser. hist. nat., 12(1), 85–92.
- Gregori, J. (2002):** Ptiči doline Dragonje, njihove ekološke značilnosti in vprašanja varstva. Varst. narave, 19, 77–88.
- Järvinen, O. & R. A. Väisänen (1975):** Estimating relative densities of breeding birds by the line transect method. Oikos, 26, 316–322.
- Lipej, L. & M. Gjerkeš (1994):** Ujede (Falconiformes) in sove (Strigiformes) Slovenske Istre. Annales, Ser. hist. Nat, 4, 53–62.
- Makovec, T., I. Škornik, L. & Lipej (1998):** Ekološko vrednotenje in varovanje pomembnih ptic Sečoveljskih solin. Falco, 13–14, 5–48.
- Perko, D. & M. Orožen Adamič (1998):** Slovenija pokrajine in ljudje. MK, Ljubljana, 735 str.
- Sovinc, A. (1998):** Ptice doline Dragonje – deset let kasneje. Annales, Ser. hist. nat., 8, 81–90.
- Škornik, I., T. Makovec & M. Miklavc (1990):** Fav-nistični pregled ptic slovenske obale. Varstv. Narave, 16, 4-99.
- Tome, D. (1998):** Ornitogeografija JZ Slovenije. Annales, Ser. hist. nat., 8, 75–80.
- Tome, D. (2000):** Sto števil Acrocephalus. Acrocephalus, 21(101), 173–176.

original scientific article
received: 2005-

UDC 599.32/.33+599.742(497.5 Korčula)

NON-VOLANT TERRESTRIAL MAMMALS (MAMMALIA) ON THE ADRIATIC ISLAND OF KORČULA

Franč JANŽEKVIČ

University of Maribor, Pedagogical Faculty, Department of Biology, SI-2000 Maribor, Koroška 160
E-mail: franc.janzekovic@uni-mb.si

Boris KRYŠTUFEK

University of Primorska, Science and Research Centre of Koper, SI-6000 Koper, Garibaldijska 18

ABSTRACT

Eleven species of non-volant terrestrial mammals are known to occur on the island of Korčula: Crocidura suaveolens, Lepus europaeus, Apodemus epimelas, A. sylvaticus, Rattus rattus, Mus domesticus, Glis glis, Eliomys quercinus, Canis aureus, Martes foina, and Herpestes auropunctatus. Rattus norvegicus has been deleted from the faunal list of the island. House mouse Mus domesticus seems to be the dominant species. Although the island of Korčula, which covers 276 km², is not the largest island in the central and southern Adriatic archipelago, it is inhabited by the largest number of non-volant mammal species. This is presumably the consequence of the following two facts: the mainland proximity that enables immigrations from the land, and the large habitat diversity within the island.

Keywords: terrestrial mammals, barn owl pellets, the island of Korčula

I MAMMIFERI TERRESTRI (MAMMALIA) DELL'ISOLA ADRIATICA DI CURZOLA

SINTESI

Nell'isola adriatica di Curzola sono state evidenziate undici specie di mammiferi terrestri (esclusi i pipistrelli): Crocidura suaveolens, Lepus europaeus, Apodemus epimelas, A. sylvaticus, Rattus rattus, Mus domesticus, Glis glis, Eliomys quercinus, Canis aureus, Martes foina, e Herpestes auropunctatus. Il ratto grigio Rattus norvegicus è stato escluso dall'elenco. La specie dominante sull'isola è rappresentata dal topolino delle case Mus domesticus. Curzola ha una superficie di 276 km² e, pur non essendo l'isola più grande fra quelle dell'Adriatico centrale e meridionale, ospita la maggior parte di specie di mammiferi. Ciò è dovuto, probabilmente, a due fattori: la vicinanza del continente, che permette la migrazione dalla terra ferma e la ricca varietà di habitat presenti sull'isola.

Parole chiave: mammiferi terrestri, borra del barbagianni, isola di Curzola

INTRODUCTION

The Eastern Adriatic coast abounds with islands, which are actually peaks or ridges of the submerged Dinaric Alps. The great majority of these islands are small, with only 67 covering ≥ 1 km²; surface area of 29 of them exceeds 10 km², while merely eight islands are larger than 100 km². It is clear therefore that most of the Adriatic islands are too small to host viable populations of the non-volant mammals, especially as their natural vegetation – consisting mainly of evergreen forests and shrubs – was severely degraded in the past centuries. The deforestation was followed by overgrazing and overbrowsing, as well as occasional intentional burnings. All these facts increased soil erosion and caused habitat degradation. On the other hand, the Adriatic islands as former parts of the continent became finally isolated after the end of the Pleistocene due to the considerable rise of the sea surface, thus the endemism is lacking (Rodić, 1970; Griffiths *et al.*, 2004).

The bulk of faunal research on the Adriatic coast was carried out in the 1960s and 1970s by B. Đulić (also spelled as Dulić or Djulić) and N. Tvrtković from the University of Zagreb. Their focus was on small terrestrial mammals (insectivores, rodents) and bats (Dulić, 1970, 1972; Đulić, 1989; Dulić & Tvrtković, 1970, 1979; Tvrtković *et al.*, 1985). Faunal composition of small mammals is thus reasonably well known (see Petrov, 1992, for a summary of insectivores and rodents). However, information on other mammalian groups has never been compiled. In this paper we report on new material and data collected recently on the island of Korčula, which allows some insight into the relative abundance of mammals and the assembly composition. Besides, we revised a faunal checklist of the island mammals, other than bats.

MATERIAL AND METHODS

Study area

The island of Korčula is situated on the southern border of the Adriatic archipelago, offshore central Dalmatia. With an area of 276 km² it is one of the largest islands in the Adriatic archipelago. Topography is diverse with the highest peak at 568 m above sea level. The bedrock is mainly of Cretaceous limestones with well-developed karst phenomena and, consequently, shortage of surface water. Climate is Mediterranean, with hot, dry summers and mild, wet winters. Mean annual temperature is c. 16 °C; average for July is c. 25.5 °C and for January c. 9 °C; mean winter temperatures are nowhere on the island below 6 °C. Annual precipitation is fairly high (c. 1100 mm), although recorded primarily between October and January.

Korčula is reported to have the best-preserved forests

on all Adriatic islands. This is somewhat surprising, considering the long history of human settling there (since the Neolithic) and the importance that shipbuilding industry had in the island's economy since the 14th century. The majority of plants are evergreen, with a moderate addition of deciduous species. Forests are composed of *Quercus ilex*, *Cupressus sempervirens*, *Pinus halepensis*, *P. pinea*, *P. nigra*, *Olea europaea*, *Myrtus communis*, *Laurus nobilis*, *Pistacia lentiscus* etc. Shrub communities include, in addition to some of the above taxa, *Erica arborea*, *Smilax aspera*, *Arbutus inede*, *Pistacia terebinthus*, *Viburnum pinus*, *Juniperus phoenicea*, *Paliurus spinachristi*, and so on. Following the changes in the island's economy of the last decades, with less grazing and browsing, shrubs expanded into impenetrable maquis.

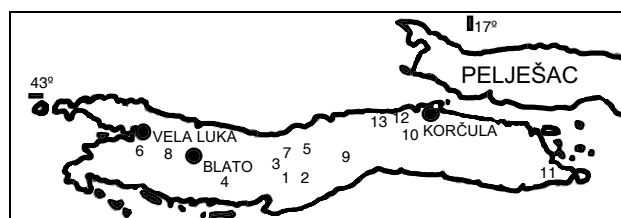


Fig. 1: Map of the island of Korčula with localities cited in text. 1 – Banja, 2 – Kruševo, 3 – Smokvica, 4 – Donji lov, 5 – Doli, 6 – Kokotovac, 7 – Sitnica, 8 – Blatsko polje, 9 – Čara, 10 – Žrnovo, 11 – Lumbarda, 12 – Žrnovska Banja, 13 – Pupnat.

Sl. 1: Zemljevid otoka Korčula z označenimi lokalitetami. 1 – Banja, 2 – Kruševo, 3 – Smokvica, 4 – Donji lov, 5 – Doli, 6 – Kokotovac, 7 – Sitnica, 8 – Blatsko polje, 9 – Čara, 10 – Žrnovo, 11 – Lumbarda, 12 – Žrnovska Banja, 13 – Pupnat.

The above information is summarised from Ivančević & Filippi (1984), Kalogjera (1985), Jovanović *et al.* (1986) and Rodić (1970).

Material and methods

Material and data were collected by the first author during the three excursions to the island in 2002, 2003, and 2004 (all in August) (Fig. 1). Local people were interviewed on the presence of mammals and roads were searched for road casualties. Main source of small mammals were remnants in the pellets of barn owl (*Tyto alba*), collected at Kruševo. The pellets were decomposed by hand, and cranial remnants identified subsequently under the stereomicroscope. Skeletal remnants of medium sized mammals were found in abandoned wells that acted as deadly pitfalls. The material is stored at the Department of Biology, University of Maribor. We also included data housed in the Slovenian Museum of

Natural History (Ljubljana).

Reference material (Slovenian Museum of Natural History) was used in identifying osteological material. Taxonomy and nomenclature follows Mitchell-Jones *et al.* (1999). Toponyms are from Babić (2003). Estimates of relative abundance are based on information that was not collected systematically and are thus entirely subjective.

In preparing the faunal list, we checked all published sources available to us. Data are widely scattered and many records on game species in particular appeared in obscure sources, e.g. in hunters' and in a popular natural history periodicals, in unpublished theses and expert reports as well as in daily press. It is beyond doubt that much of such data, no matter how valuable they are, escaped our attention. The only compilation on small terrestrial mammals (insectivores and rodents) is by Petrov (1992). A detailed crosschecking of this published source, however, detected numerous inaccuracies and errors that induced us to verify all the original literary sources.

Results and Discussion

The new data on non-volant mammals of the island of Korčula are summarised in Tables 1 and 2. It is evident that small mammal assembly is poor in species composition with a high predominance of house mice (*Mus domesticus*). Since the barn owl is a feeding generalist (Mikkola, 1983), one would expect a broader spectrum of the island rodents to be represented in pellets, but the remains of 168 prey specimens belonged to only four species. Although the pooled sample from wells contained only 41 individuals, no less than seven species were represented. Again, house mice dominated, but share of the two carnivores, the mongoose (*Herpestes auropunctatus*) and stone marten (*Martes foina*), was surprisingly high (= 21% of specimens). High abundance of carnivores in a taphonomic sample unlikely reflects their actual share in mammal assembly. In any case, in wells it was much easier to overlook remnants of small shrews and rodents than those of carnivores.

Tab. 1: Mammal species in 75 barn owl pellets from Kruševo (the island of Korčula).

Tab. 1: Sesalci, izolirani iz 75 izbljuvkov pegaste sove, lokaliteta Kruševo, otok Korčula.

Species	No. of individuals	%
<i>Crocidura suaveolens</i>	7	4.1
<i>Apodemus sylvaticus</i>	8	4.7
<i>Mus domesticus</i>	135	79.9
<i>Rattus rattus</i>	18	10.7
Total	168	100.0

Tab. 2: Mammal species in tanatocenoses of abandoned wells according to locality. A minimal number of specimens is given. For localities, see figure 1.

Tab. 2: Tanatocenoza sesalcev, najdenih v zapuščenih vodnjakih. Podano je minimalno število osebkov. Za lokalitete glej sliko 1.

Locality	1	2	3	4	5	6	7	Total	%
Species									
<i>Crocidura suaveolens</i>		1			4	1		6	14
<i>Apodemus sylvaticus</i>			1		2			3	7
<i>Rattus rattus</i>	1			4	1	1	1	8	20
<i>Mus domesticus</i>					3	5	4	12	30
<i>Glis glis</i>		1		2				3	7
<i>Martes foina</i>	1			3				4	10
<i>Herpestes auropunctatus</i>	2	1		1	1			5	12
No. of specimens	4	3	1	10	11	7	5	41	100

Faunal list

In the list below, the literature and our own data are presented. In the subsequent text we paid attention to avoid confusion between the island of Korčula and the town of Korčula.

Crocidura suaveolens (Pallas, 1811)

Published data: Blato; Čara (Đulić, 1976).

New data: Doli (2002); Kruševo (2002, 2003); Koko-tovac (2004).

The lesser white-toothed shrew is the only insectivore on the island. Đulić (1976) reports only on three specimens from two different localities. As one can deduce from owl pellet sample, it is fairly rare in the small mammal assembly.

Lepus europaeus Pallas, 1778

New data: Blatsko polje (2003).

Record is based on road casualty. The origin of the European hare on the island of Korčula is not known, but we assume it is due to introduction. In the past, this popular game species was frequently imported to various Adriatic islands for hunting purposes. Animals mainly originated from Central European lowlands, and the success was usually low. Current status of the hare on the Adriatic islands is not known.

Apodemus epimelas (Nehring, 1902)

Published data (as *A. mystacinus*): the island of Korčula (Đulić, 1972). Žrnovo (Petrov, 1992).

Besides the island of Mljet, Korčula is the only Adri-

atic island populated by karst mouse (Petrov, 1992). Dulić (1972) reported it for the island without any further details. So far, Petrov (1992) provides the only exact locality and credits Đulić for it. This species was not present in our samples.

The rarity of *A. epimelas* on the Adriatic islands is somehow surprising, since the closely related *A. mystacinus* is widespread on the Aegean islands (Mitchell-Jones *et al.*, 1999).

***Apodemus sylvaticus* (Linnaeus, 1758)**

Published data: the island of Korčula (Dulić, 1972; Dulić & Tvrtković, 1971, 1972; Tvrtković, 1976a, b, 1979). Čara; Lumbarda (Petrov, 1992).

New data: Smokvica (2002); Kruševo (2002); Doli (2002).

Đulić and Tvrtković (see citations above) did not refer to any exact locality from the island. Petrov (1992), on the other hand, claims that two localities (Čara and Lumbarda) are cited on the basis of their papers. As one can deduced from our samples, this wood mouse is fairly rare on the island.

The population from the island of Korčula is characterised by large size (Tvrtković, 1976a) and low frequency in the presence of the postero-labial tubercle (T_{12}) on the first upper molar (Tvrtković, 1976b).

***Rattus rattus* (Linnaeus, 1758)**

Published data: Žrnovska Banja (Kataranovski *et al.*, 1989).

New data: Doli (2002); Kruševo (2003); Sitnica (2002); Banja (2002); Kokotovac (2004); Donji lov (2003); Žrnovo (2003).

On the Adriatic islands, the black rat is a common species (own observations), both in synanthropic and feral populations. The island of Korčula seemingly does not deviate in this respect. Since the barn owl does not prey on adult rats, the data in Table 1 do not rely on the actual species frequencies within the small mammal communities. In August 2003, a specimen was trapped in dense maquis c. 2 m high.

***Rattus norvegicus* (Berkenhout, 1769)**

Published data: Žrnovska Banja (Petrov 1992).

Petrov (1992) refers to a communication by Kataranovski *et al.* (1989), which was published as an abstract. This is certainly an error since the above citation deals entirely with *R. rattus*, not mentioning at all *R. norvegicus*. The brown rat is thus to be deleted from the faunal list of the island.

***Mus domesticus* (Schwartz et Schwartz, 1943)**

Published data (all in Dulić & Tvrtković, 1979): Vela

Luka; Smokvica (as *Mus musculus pretextus* x *M. m. brevirostris*). Blato; Smokvica; Čara; Lumbarda (as *Mus musculus brevirostris*).

New data: Doli (2002); Kruševo (2002, 2003); Sitnica (2002); Kokotovac (2004).

On the islands of southern Adriatic, Dulić & Tvrtković (1972) collected house mice in urban settlements, in bushes bordering the arable land, and in a small wood, but was the most common in riverine habitats and in marshes. Our data suggest this species to be the dominant small mammal on the island.

***Glis glis* (Linnaeus 1766)**

Published data: the island of Korčula (as *Glis glis postus*; Dulić, 1972). Žrnovo (as *Myoxus glis*; Petrov, 1992).

New data: Kruševo (2002); Donji lov (2003); Žrnovo (2003, leg.: D. Pavlin).

The edible dormouse is widespread on the Southern Adriatic islands, but was rare in taphonomic material from Korčula. Eight specimens were trapped in dense maquis at Žrnovo between August 5 and 6, 2003.

***Eliomys quercinus* (Linnaeus, 1766)**

Published data: the island of Korčula (Đulić, 1971); Pupnat (Tvrtković *et al.*, 1995).

Although the garden dormouse is fairly widespread on the Adriatic islands, it is seemingly rare on Korčula. We do not have it in our material.

***Canis aureus* Linnaeus, 1758**

Published data: numerous but scattered in hunting and popular natural history journals, as well as in daily press. The only museum specimen (skull) from Korčula (from 1907 no exact locality) is reported by Kryštufek & Tvrtković (1990b).

The jackal was documented on the island of Korčula for the first time as early as in 1491 (Jeričević, 1952) and its presence on the island was seemingly continuous until recently (Kryštufek & Tvrtković, 1990a). Since this animal is a keen swimmer (Kapitan, 1919), it is likely that the island was repeatedly colonised from the nearby Pelješac Peninsula, where the jackal is common as well (Jeričević, 1952). Kühn (1935) refers to the Archives of the city of Dubrovnik (Ragusa), according to which the Venetian Republic had brought jackals from Africa and released them on the island of Korčula, then the property of the Republic of Dubrovnik, with intention to cause harm. The presumption on the African origin of Dalmatian jackals was known already to Fitzinger (1830), but is not supported by cranial data. Morphometric evidence placed Dalmatian jackals close to their

counterparts from the rest of the Balkans and from Asia Minor, rather than to those from Africa. Jackals living on the Balkan Peninsula thus most likely arrived via a Bosphorus land bridge during some of the low sea level phases of the Upper Pleistocene (Kryštufek & Tvrković, 1990b), although one cannot exclude more recent colonisations by swimming across the narrow straits of Bosphorus and Dardanelle.

Throughout the history, the jackal was invariably considered to be a characteristic inhabitant of the island (Morgan, 1906), and the municipality of Blato has it in its coat of arms (Jeričević, 1952). Besides, jackals were constantly reported to cause damage. On Korčula, eradication campaigns were undertaken as early as in 15th century. For the 16th century, Jeričević (1952) lists three such campaigns, two in 1576 and one in 1579. Although the two pursuits in 1576 lasted 30 and 18 days, respectively, none of them were successful. Eradication campaigns are known also from the 20th century, e.g. in the 1930s (Ivković, 1932, 1933; Jeričević, 1952). The annual bag in the period 1964-1974, reported as 50 jackals (Borčić *et al.*, 1990), is possibly an overestimate (= 1.8 jackal killed per 10 km²). Nevertheless, Borčić *et al.* (1990) suggest that relatively high incidence of kala-azar (visceral leishmaniosis) on the island of Korčula is possibly connected to the high density of jackals, presumably the main reservoir of the disease. According to the personal communications by local hunters, the jackal is still present on the island.

***Martes foina* (Erxleben, 1777)**

Published data: the island of Korčula (Tvrković, 1996; cited from Baltić, 2000).

New data: Banja (2002); Donji lov (2003).

Stone marten is widespread on the larger Adriatic islands, including those in the southern part of Dalmatia: Brač, Hvar, Mljet, and Lastovo (Baltić, 2000). History of the species, however, seems to be unknown. We identified in or taphonomic material four martens and five mongooses, which suggests the two carnivores to be approximately equally common.

***Herpestes auropunctatus* (Hodgson, 1836)**

Literature data: Blato (Tvrković & Kryštufek, 1990); Vela Luka (Niethammer & Krapp, 1993); near Lumbarda (Cavallini & Serafini, 1995).

New data: Blato (1 May 1997, leg.: A. Vrezec); Doli (2002); Kruševo (2003); Banja (2002); Donji lov (2003).

The lesser Indian mongoose was introduced onto the island of Korčula on July 13th, 1920, from India and subsequently translocated onto some other nearby islands. For history and taxonomic identity, see Tvrković &

Kryštufek (1990). The species is widespread and abundant enough to be considered a pest. Its successful acclimatisation is somehow surprising, since the January 10 °C isotherm was suggested to predict its most northerly distribution (Ebisu & Whittow, 1976); the corresponding values on the island of Korčula are c. 6-9 °C. Winter diet on Korčula is dominated by vertebrates (mostly murine rodents) and plant matter (Cavallini & Serafini, 1995).

Zoogeography

The summary data on the distribution of non-volant terrestrial mammals on the larger Central and Southern Dalmatian islands are presented in Table 3. According to its surface area, the island of Korčula ranks in the third place among these islands, but it is the richest in the archipelago with respect to non-volant mammal species.

Although in some islands the presence of the brown hare could escape the notice, the total numbers of species presumably reflect the general real state. There are two probable reasons causing the highest species richness on the island of Korčula: (1) the "rescue effect" and (2) the insular habitat diversity.

The jackal, being absent in the two larger islands and reported only once from Mljet, possibly survived on the island of Korčula due to the "rescue effect" (Brown, 1995). The shortest distance to the mainland (1.2 km) is much lesser than for any other nearby island, presumably allowing frequent arrival onto the island. This is believed to be the reason, why the species has lived on the island of Korčula at least since the 15th century, in spite of its relative small area and permanent attempts to exterminate it. We assume that the jackal rarely reached the other islands, and that permanent populations have never been established.

As already stated, vegetation is less degraded on Korčula than on the other islands. We ascribe a sympatric occurrence of two *Apodemus* species, as well as of two dormice, to niche availability in a more complex and structured habitat. If our assumption is valid, then the habitat diversity of Korčula compensates for its smaller surface area.

To summarise, the sympatric occurrence of relatively high number of non-volant mammals on the island of Korčula in comparison with the other Adriatic islands reflects well preserved vegetation on the island causing large niche availability within different habitats. This is why it has not been elucidated why the generalist hedgehog species *Erinaceus concolor*, otherwise widely spread on the Adriatic islands (Petrov, 1992), is missing of the island.

Tab. 3: Occurrence of non-volant terrestrial mammals on the larger islands of the Central and Southern Adriatic. Compiled from Kryštufek & Tvrtković (1990a), Tvrtković & Kryštufek (1990), Petrov (1992), and Baltić (2000). The distribution of *Lepus europaeus* is most likely underestimated. Parentheses indicate historical occurrence, not considered in sums. Notes: ¹present in the 1920s and 1930s (Tvrtković & Kryštufek, 1990a); ²recorded once before 1920 (Kapitan, 1919).

Tab. 3: Seznam terestričnih sesalcev (brez netopirjev) na večjih otokih srednjega in južnega Jadrana. Povzeto po Kryštufek & Tvrtković (1990a), Tvrtković & Kryštufek (1990), Petrov (1992), in Baltić (2000). Domnevamo, da je razširjenost *Lepus europaeus* podcenjena. Starejša opazovanja so v oklepajih in niso všteta v seštevek vrst. Opomba: ¹zabeležen leta 1920 in 1930 (Tvrtković & Kryštufek, 1990a); ²eno opazovanje pred letom 1920 (Kapitan, 1919).

Island	Brač	Hvar	Korčula	Mljet	Vis	Lastovo	No. of islands
Area (km ²)	395	300	276	100	90	47	
Species							
<i>Erinaceus concolor</i>	+	+		+	+	+	5
<i>Crocidura suaveolens</i>	+	+	+			+	4
<i>Lepus europaeus</i>			+		+		2
<i>Apodemus sylvaticus</i>	+	+	+	+	+	+	5
<i>Apodemus epimelas</i>			+	+			2
<i>Mus domesticus</i>	+	+	+	+	+	+	6
<i>Rattus rattus</i>	+	+	+		+		4
<i>Glis glis</i>	+	+	+	+			4
<i>Eliomys quercinus</i>	+	+	+				3
<i>Martes foina</i>	+	+	+	+		+	5
<i>Herpestes auropunctatus</i>	(+) ¹	+	+	+			3
<i>Canis aureus</i>			+	(+) ²			1
No. of species	8	9	11	6	5	5	

ACKNOWLEDGEMENTS

For the access to the Indian mongoose specimen we thank Al Vrezec (Ljubljana), and for dormice we are

grateful to Dušan Pavlin. We are indebted to Alen Andrijić (Brna, Korčula) for the information on the mammals of Korčula Island, and to Tone Novak (University of Maribor) for his comments on the earlier draft.

KOPENSKI SESALCI (MAMMALIA) OTOKA KORČULA V JADRANSKEM MORJU

Franc JANŽEKOVIC

Univerza v Mariboru, Pedagoška fakulteta, Oddelek za biologijo, SI-2000 Maribor, Koroška 160
E-mail: franc.janzekovic@uni-mb.si

Boris KRYŠTUFEK

Univerza na Primorskem, Znanstveno-raziskovalno središče Koper, SI-6000 Koper, Garibaldijska 18

POVZETEK

Na otoku Korčula v Jadranskem morju smo ugotovili enajst vrst kopenskih sesalcev (brez netopirjev): *Crocidura suaveolens*, *Lepus europaeus*, *Apodemus epimelas*, *A. sylvaticus*, *Rattus rattus*, *Mus domesticus*, *Glis glis*, *Eliomys quercinus*, *Canis aureus*, *Martes foina* in *Herpestes auropunctatus*. Sivo podgano *Rattus norvegicus* smo črtali s seznama sesalcev Korčule. Dominantna vrsta na otoku je bila hišna miš *Mus domesticus*. Otok Korčula meri 276 km² in čeprav ni največji otok srednjega in južnega jadranskega arhipelaga, na njem živi največ sesalčjih vrst. Domnevamo, da je to posledica dveh dejstev: bližine celine, ki omogoča imigracijo s kopnega, in visoke pestrosti habitatov na otoku.

Ključne besede: kopenski sesalci, izbljuvki pegaste sove, otok Korčula

REFERENCES

- Babić, B. (2003):** Korčula. Tourist road map. Kartograf d.o.o., Zagreb.
- Baltić, M. (2000):** Prehrana kune bjelice *Martes foina* (Erxleben, 1777) na otoku Cresu. Unpublished M.Sc. Thesis. Sveučilište u Zagrebu, Prirodoslovno-matematički fakultet, Biološki odsjek, Zagreb.
- Borčić, B., N. Tvrtković & S. Komarak (1990):** Kala-azar na jadranskom priobalju – otok Korčula kao epidemiološki model. *Pomorska medicina*, 5, 461–467.
- Brown, J. H. (1995):** Macroecology. The University of Chicago Press, Chicago, 284 pp.
- Cavallini, P. & P. Serafini (1995):** Winter diet of the small Indian mongoose, *Herpestes auropunctatus*, on an Adriatic Island. *J. Mammalogy*, 76, 569–574.
- Dulić, B. (1970):** Ökologische Beobachtungen der Fledermäuse der Adriatischen Inseln. *Z. Säugetierkunde*, 35, 45–51.
- Dulić, B. (1972):** Position géographique des quelques îles de l'Adriatique méridionale. *Rapp. Comm. int. Mer Médit.*, 20, 559–561.
- Dulić, B. & N. Tvrtković (1970):** The distribution of bats on the Adriatic Islands. *Bijdr. Dierkd.*, 40, 17–20.
- Dulić, B. & N. Tvrtković (1971):** Some problems on taxonomy of *Apodemus sylvaticus* Linn., 1758, and *Apodemus flavicollis* Melchior, 1834, in Yugoslavia. In: Kratochvíl, J. & R. Obrtel (eds.): Symposium Theriologicum II. Proceedings of the International symposium on species and zoogeography of European mammals. Academia, Praha, p. 183–189.
- Dulić, B. & N. Tvrtković (1972):** Sur la possibilité de la différentiation des populations de mulot (*Apodemus sylvaticus* Linne, 1758) et du mulot fauve (*Apodemus flavicollis* Melchior, 1834) dans les îles de l'Adriatique. *Rapp. Comm. int. Mer Médit.*, 21, 101–104.
- Dulić, B. & N. Tvrtković (1979):** On some mammals from the Centraladriatic and Southadriatic islands. *Acta Biologica, Prirodoslovna istraživanja*, 43, 15–35.
- Đulić, B. (1971):** Značajni sisavci Dinarskog krša i njihove ekološke karakteristike. In: Simpozij o zaštiti prirode u našem kršu. JAZU, Zagreb, p. 213–237.
- Đulić, B. (1976):** Taxonomic position of *Crociodura suaveolens* (Pallas, 1811) (Mammalia, Insectivora) from the Adriatic Islands. *Biostatematika*, 2, 143–152.
- Đulić, B. (1989):** Ekološke značajke sisavaca otoka Mljet. In: Otok Mljet. Ekološke i zdravstvene prilike. JAZU, Razred za medicinske znanosti, Zagreb, p. 57–61.
- Ebisu, R. J. & G. C. Whittow (1976):** Temperature regulation in the small Indian mongoose (*Herpestes auropunctatus*). *Comp. Biochem. Physiol. A.*, 54, 309–313.
- Fitzinger, L. J. (1830):** Über den Schakal Dalmatiens. *Isis*, 1830, p. 372–375.
- Griffiths, H. I., B. Kryštufek & J. M. Reed (eds.) (2004):** Balkan biodiversity. Pattern and process in the European hotspot. Kluwer Academic Publishers, Dordrecht, 367 pp.
- Ivković, S. (1932):** Hajka na čagljeve lovačkog društva Blato na Korčuli. *Lovačko ribarski vjesnik*, 1932, p. 226–230.
- Ivković, S. (1933):** Hajka na čagljeve na Korčuli. *Lovačko ribarski vjesnik*, 1933, p. 73–85.
- Ivančević, N. & Ž. Filippi (1984):** Vodič Korčule. Logos, Split.
- Jeričević, I. (1952):** Čagalj. Mala lovačka biblioteka, 24. Savez lovačkih društava N. R. Hrvatske, Zagreb.
- Jovanović, B., R. Jovanović & M. Zupančič (eds.) (1986):** Natural potential vegetation of Yugoslavia. Scientific Council of Vegetation Map of Yugoslavia, Ljubljana.
- Kalogjera, D. (1985):** Otok Korčula, Pelješka rivijera. Grafički zavod Hrvatske, Zagreb.
- Kapitan, Z. (1919):** Šakal. *Lovec*, 6, 13–18.
- Kataranovski, D., I. R. Savić & P. Cakić (1989):** Fertilitet crnog pacova (*Rattus rattus* L.). In: Vasić, V. (ed.): Treći simpozij o fauni SR Srbije. Uvodni referati i rezimeji. Prirodnački muzej Beograd, Beograd, p. 66.
- Kryštufek, B. & N. Tvrtković (1990a):** Range expansion by Dalmatian jackal population in the 20th century (*Canis aureus* Linnaeus, 1758). *Folia Zool.*, 39, 291–296.
- Kryštufek, B. & N. Tvrtković (1990b):** Variability and identity of the jackals (*Canis aureus*) of Dalmatia. *Ann. Nat. Hist. Mus. Wien B.*, 91, 7–25.
- Kühn, W. (1935):** Die Dalmatinischen Schakale. *Z. Säugetierkd.*, 10, 144–146.
- Mikkola, H. (1983):** Owls of Europe. Poyser Ltd, Carlton.
- Mitchell-Jones, A. J., G. Amori, W. Bogdanowicz, B. Kryštufek, P. J. H. Reijnders, F. Spitzenberger, M. Stubbe, J. B. M. Thissen, V. Vohralík & J. Zima (eds.) (1999):** The Atlas of European mammals. Poyser Ltd, London.
- Morgan, C. (1906):** Der Schakal Dalmatiens. Wien.
- Niethammer, J. & F. Krapp (eds.) (1993):** Handbuch der Säugetiere Europas. Bd. 5, Raubsäuger, Carnivora (Fissipedia). Aula, Wiesbaden.
- Petrov, B. M. (1992):** Mammals of Yugoslavia. Insectivores and rodents. Natural History Museum, Belgrade, 37, p. 1–186.
- Rodić, D. (1970):** Geografija Jugoslavije I. Naučna knjiga, Beograd.
- Tvrtković, N. (1976a):** Les caractères morphologiques de l'espèce *Apodemus sylvaticus* Linne, 1758 dans les îles de l'Adriatique. *Rapp. Comm. int. Mer Médit.*, 23, 35–36.
- Tvrtković, N. (1976b):** The variability of the postero-external supplemental tubercle (T₁₂) on the first and second upper molars in the species *Apodemus sylvaticus* (Linne, 1758) and *Apodemus flavicollis* (Melchior, 1834) from western Yugoslavia. *Period. Biol.*, 78, 91–100.
- Tvrtković, N. (1979):** Razlikovanje i određivanje morfološki sličnih vrsta podroda *Sylvaemus* Ognev et Vorobiev, 1923 (Rodentia, Mammalia). *Rad JAZU*, 383, 155–186.

Tvrtković, N. (ed.) (1996): Popis endemične flore, faune kralješnjaka i podzemne faune hrvatskih otoka Jadrana. Ministarstvo razvitka i obnove, Zagreb. *Unpubl. Report.*

Tvrtković, N. & B. Kryštufek (1990): Small Indian mongoose *Herpestes auropunctatus* (Hodgson, 1836) on the Adriatic Islands of Yugoslavia. *Bonn. Zool. Beitr.*, 41, 3–8.

Tvrtković, N., B. Dulić & M. Mrakovčić (1985): Distribution of insectivores and rodents on the north-east Adriatic coast. *Acta Zool. Fennica*, 170, 201–203.

Tvrtković, N., B. Dulić & M. Grubešić (1995): Distribution and habitats of dormice in Croatia. *Hystrix (N.S.)*, 6, 199–207.

pregledni znanstveni članek
prejeto: 2005-04-05

UDK 551.7:552.54(497.4)

VREMSKE PLASTI SKOZI ZGODOVINO

Rajko PAVLOVEC

Univerza v Ljubljani, Naravoslovnotehniška fakulteta, Oddelek za geologijo, SI-1000 Ljubljana, Aškerčeva 2
E-mail: rajko.pavlovec@ff.uni-lj.si

IZVLEČEK

Vremse plasti iz jugozahodne Slovenije so prvotno imenovali spodnjeforaminiferni (imperforatni) apnenci. Deloma so jih uvrščali v kreda, deloma v terciar. Danes vemo, da so zgornjemaastrichtijske starosti.

Ključne besede: zgornja kreda, plitvomorski apnenci, vremseke plasti, Slovenija

STRATI DI VREME ATTRAVERSO LA STORIA

SINTESI

Gli strati di Vreme della Slovenia sud-occidentale venivano chiamati calcari basso-foraminiferi (imperforati). Si supponeva che la loro origine risalisse al cretaceo, parzialmente al terziario. Oggi è noto che risalgono al Maastrichtiano superiore.

Parole chiave: cretaceo superiore, calcari di acque poco profonde, strati di Vreme, Slovenia

UVOD

V nastajajočem slovenskem geološkem terminološkem slovarju je za vremške plasti naslednja oznaka: "Zgornjekredni skladnat apnenec s plastmi črnega premoga pri Vremškem Britofu in Lipici". Spadajo v spodnji del liburnijske formacije (liburnijske stopnje po Stacheju, 1872a, 1889), ki jo je Stache prvič omenjal leta 1859 iz južne Slovenije ter 1864 in 1867 iz območja med Trstom in Kvarnerjem. Čeprav so ti podatki stari skoraj 150 let, "nas presenetijo z izredno natančnostjo zaključkov oziroma jasnostjo prikazovanja problemov" (Pavlovec, 1963). Stache je starejši del liburnijske formacije postavil na prehod iz krede v terciar, deloma v danij (takrat še kot kredna stopnja), deloma v terciar. Poleg različnih imen za kompleks, ki ga danes imenujemo vremške plasti, so te glede starosti povzročale tudi poznejšim raziskovalcem precej težav. Danes je jasno, da so vremške plasti maastrichtijske starosti (Bignot, 1972).

Najznačilnejše vremške plasti so v okolici Vremškega Britofa, Lipice in še nekaterih krajev v jugozahodni Sloveniji. Nekoliko manj značilni ekvivalenti so v Istri in Dalmaciji, in vprašanje je, ali jih lahko označujemo z enakim imenom. Vremške plasti so plastnati temnosivi apneneci z redkejšimi lapornatimi vložki in plastmi premoga. Produktivne liburnijske plasti je poleg drugih natančneje opisal Hamrla (1960), ki je celoten kompleks imenoval liburnik. Klasičen profil pri Vremškem Britofu sta opisala Hötzel & Pavlovec (1979). Veliko je k razpravljanju o starosti in načinu sedimentacije vremških plasti prispeval s svojimi raziskavami in opazovanji Pleničar (1961, 1968).

POIMENOVANJE IN STAROST

Na začetku je Stache (1859–1867) ločil kozinske plasti ter foraminiferne apnenice. Liburnijsko formacijo je podrobneje opisal leta 1889. Razdelil jo je na spodnjeforminiferne (imperforatne) apnenice, kozinske plasti z vložki glavnega haracejskega apnenca, in zgornjeforminiferne (imperforatne) apnenice. Že Stache (1872b) je omenjal, da bi bilo treba spodnje in zgornjeforminiferne apnenice drugače poimenovati. V spodnji del ne uvrščamo samo plasti z miliolidami, marveč tudi plasti z giroplevrami, aprikardijami in rapidioninami (Pavlovec, 1963). Značilni razvoj tega dela liburnijske formacije je Pleničarjev (1961) profil števil. 1 iz okolice Vremškega Britofa in Vrem. Po teh krajih je Pavlovec (1963) imenoval vremške plasti in jih uvrstil v danij kot najstarejšo paleocensko stopnjo. Pripominja pa, da spodnje meje ni bilo mogoče natančno določiti in da segajo starejše plasti morda še v maastrichtij.

Glede starosti vremških plasti so bila v preteklosti različna mišljenja. Haug (1908–1911) pravi, da so liburnijske plasti po določitvah rudistov danijske (kreda),

sladkovodne in brakične, nad njimi pa thanetijske. Bubnoff (1956) ima spodnji imperforatni apnenec za danij, kozinske plasti za montij. Hamrla (1960) in Pleničar (1961) sta imenovala plasti z giroplevrami, torej vremške plasti, morski horizont. Školjke iz rodu *Gyropleura* so po Pleničarju visoko specializirani rudisti, torej so plasti z njimi kredne. Kasneje je Pleničar (1993) iz istih plasti opisal še vrsto *Apricardia pachiniana* Sina. Pavlovec & Pleničar (1979, 1981) sta celoten kompleks plasti od maastrichtija do eocena označila kot liburnijsko formacijo v smislu kronolitološke enote. Podroben profil vremških plasti pri Vremškem Britofu je objavil Knez (1994). Jurkovšek *et al.* (1996) pa so se odločili za vremski facies, ki ga uvrščajo v zgornji maastrichtij.



Sl. 1: Vremške plasti z vložki horizontov, polnih školjk iz rodov *Gyropleura* in *Apricardia*, ob cesti Senožče – Divača.

Fig. 1: Vreme beds with intercalations, full of shells of the genus *Gyropleura* and *Apricardia*, along the Senožče – Divača road, SW Slovenia.

Po mnogih različnih starostnih interpretacijah je Bignot (1972) prvi jasno postavil vremške plasti v maastrichtij, še zlasti ker je vse bolj prevladovalo sta-

Erläuterungen
zu den Blättern
der geologischen Karte von Österreich
Görz-Gradiska und Triest

Das Gebiet ~~dieser~~ ^(Görz-Gradiska und Triest) Kartenblätter steht in so engem Zusammenhang und hat in seiner Vereinigung in mehrfacher Richtung ^{eine} ~~so~~ ^{eigenartige} Bedeutung innerhalb des gesamten nördlichen Hauptabschnittes der österreichischen Küstenländer, dass eine abgesonderte Behandlung eines jeden ~~der~~ ^{beider} Küstenland-Abschnitte sich als unpraktisch erweisen würde.

Das Festland

Die Gebirge und Flachland ~~Anteile~~ ^{Anteile} des Karten-Gebietes ^{umfassen} ~~mit~~ ⁱⁿ verschiedenen artigen Küstenlinien ~~den~~ ^{den} nördlichen Abschluss der Adriatischen Meerestromlinie Grado-Punta Salvore ins Land eingreifenden Golf von Triest.

Ausser ~~dieser~~ ^{der} Bedeutung als Vorwandung ~~an~~ ^{als} Küstengebiet ~~hat~~ ^{hat} das Gebiet ~~Wichtigkeit~~ ^{Wichtigkeit} als geographisches und geologisches Bindeglied.

Obgleich vorausgesetzt werden kann, dass nur, wenn eines der beiden Blätter allein gekauft werden wird, soll das ~~das~~ ^{das} Gesamtgebiet gewidmete Erläuterungsbuch ohne Preiserhöhung deshalb auch für den einzelnen Käufer beigegeben werden.

Im Norden bildet das Kartenblatt Tolmein (Kol. IX. Zone 21)
 - im Osten das Kartenblatt Adelsberg (Kol. X. Zone 22)
 und das Kartenblatt Tessara - St. Peter (Kol. X. Zone 23)
 die geschlossene Umrahmung des Gebirgs-
 gebietes in den Blättern Görz u. Triest dar-
 gestellten Gebirgsabteils.
 Für den Terrainabschluss im Süden kommt
 das Karotz. Flugsgebiet des Blattes Cittanova -
Montona (Kol. IX. Zone 24) in Betracht.
 Die östliche Grenzlinie durchschneidet ^{im Verlauf bis zum Lagunengebiet}
 (von 46° bis 45° 44') ~~das nördliche Drittel~~ ^{das nördliche Drittel} ~~der Natissamündung~~
~~das friaulische Flachland~~ ^{das friaulische Flachland}

Sl. 2: Osnutek rokopisa G. Stacheja za geološka zemljevida Gorica – Gradiška (Stache, 1920a) in Trst (Stache, 1920b), na katerih so tudi plasti liburnijske formacije. Zemljevida sta izšla šele leta 1920, torej malo pred njegovo smrtjo, deloma "na večkratno Tellerjevo prigovarjanje" (Rakovec, 1967). Kopijo rokopisa je ljubeznivo posredoval dunajski geološki zavod.

Fig. 2: The draft of Stache's manuscript of geological maps Görz – Gradiška (Gorizia – Gradiška) (Stache, 1920a) and Trieste (Trst) (Stache, 1920b). The maps were not published until 1920, which was just before his death and after the "repeated persuasions by Teller" (Rakovec, 1967). The draft of the manuscript by courtesy of the Geological Survey of Austria, Vienna.

lišče, da je danij najstarejša paleocenska stopnja. Pavlovec & Pleničar (1979) sta mislila na mejo kreda – terciar znotraj vremskih plasti ali celo nad njimi. Mastrichtijsko ali po nekaterih še točneje zgornjemastrichtijsko starost so navajali Pavšič & Pleničar (1981), Hötzl & Pavlovec (1979, 1981), Pavlovec & Pleničar (1983) in Jurkovšek et al. (1996).

PALEOGEOGRAFIJA

Z okoljem, v kakršnem so nastajale vremske plasti, se je ukvarjal Knez (1994). Opiral se je predvsem na giroplevre in ločil pet tipov sedimentacije. Osnovna njegova trditev je, da so bile giroplevre prenešene iz kraja, kjer so živele, predvsem v smeri proti obali. Po načinu kopičenja lupin in njihovi ohranjenosti razmišlja Knez (*ibid.*) o deloma šibkih in deloma močnejših tokovih in valovih. Morje pa je bilo med nastajanjem vremskih plasti plitvo, o čemer sklepa predvsem po znatni debelini dolomitiziranih laminarnih apnencev. Tudi Jurkovšek et al. (1996) pravijo, da je pri vremskem faciesu energijski indeks povečini zelo nizek. Bignot (1972) piše o plitvem in dobro prezračevanem morju.

Plasti z *Rhapydionina liburnica* (Stache) kažejo na izrazito lagunsko okolje (Knez, 1994).

Na okolje v času nastajanja vremskih plasti sklepamo delno tudi po haracejah, ki so sicer pogostejše v kozinskih plasteh. O njih je večkrat pisal Stache (1872a, 1872b, 1872c, 1889). Njegovi haracejski travniki naj bi kazali na zaprta sladkovodna jezera. Vendar so v vremskih in kozinskih plasteh pogosto samo oogoniji haracej, pri čemer je mogoče misliti na njihovo prenašanje s tekočimi vodami ali tokovi (Pavlovec, 1963). Zato bi o sladkovodnem okolju lahko govorili predvsem pri plasteh, v katerih so ohranjene celotne rastline. Plasti s samimi oogoniji so lahko morske.

Aubouin & Neumann (1960) sta po foraminiferah sklepala na epikontinentalno okolje. Tudi Pavlovec & Pleničar (1983) mislita na nastanek vremskih plasti v plitvem morju blizu obale ali celo v zalivih in lagunah. Veliko organogenega materiala v teh plasteh kaže na močan vpliv s kopnega. Ne izključujeta možnosti, da so vsaj ponekod vremske plasti in rudisti nastajali istočasno. Dejansko so bili pri Dolenji vasi blizu Senožeč najdeni rudisti v vremskih plasteh (Pavlovec & Pleničar, 1983).

ZAKLJUČEK

Vremске plasti so geologi po dolgotrajnih raziskovanjih in razmišljanjih postavili v zgornji maastrichtij in prepričani so, da so nastajale v plitvomorskem, delno morda v brakičnem okolju.

Ob koncu še zanimiva anekdota. Na Prvem kolokviju o geologiji Dinaridov je Pleničar (1968) med svojim predavanjem postavil vremске plasti v najvišji del krede in dopuščal lagunski, brakični ali celo sladkovodni nastanek. Na istem kolokviju je Pavlovec (1968) trdil, da je pod vremskimi plastmi našel globorotalije (Pavlovec,

1963) in da so vremске plasti zatorej terciarne. Vendar je že takrat Pleničar v svojem referatu pripomnil, da omenjene foraminifere niso dovolj značilne za globorotalije in da so bile povrh najdene samo v zbruskih.

Na omenjenem simpoziju so bili številni geologi iz celotne takratne Jugoslavije. Nekateri so se pridružili Pleničarjevi, drugi Pavlovčevi interpretaciji. Oba avtorja sta se v šali dogovorila, da bosta počakala, kaj bodo prinesle prihodnje raziskave, in da bosta potem skupaj objavila članek. To se je resnično zgodilo nekaj let pozneje (Pavlovec & Pleničar, 1979, 1981).

VREME BEDS THROUGH HISTORY

Rajko PAVLOVEC

University of Ljubljana, Faculty of Natural Sciences and Engineering, Department of Geology, SI-1000 Slovenia, Aškerčeva 2

E-mail: rajko.pavlovec@ff.uni-lj.si

SUMMARY

Vreme beds in southwestern Slovenia, formerly called the lower foraminiferal (imperforated) limestones, have caused many problems throughout history. They are the oldest part of the Liburnian Formation with type locality at Vremski Britof in southwestern Slovenia. They were partly placed into Cretaceous partly into Tertiary. Vreme beds developed as dark grey limestones with rare intercalations of marl and coal, which had also been mined in some places near Lipica and Vremski Britof. Most typical among the fossils in the Vreme beds are next miliolids the foraminifer Rhapydionina liburnica and shells Gyropleura and Apricardia. The sediments and the fossils indicate the shallow-sea. Nowadays it is known that Vreme beds are of the Maastrichtian age.

Key words: Upper Cretaceous, shallow-sea limestones, Vreme beds, Slovenia

LITERATURA

Aubouin, J. & M. Neumann (1960): Sur la géologie de l'Istrie méridionale. Comparaison avec les régions dinariques et helléniques correspondantes. Bull. Soc. Geol. Fr. 7, 2, 388–395.

Bignot, G. (1972): Recherches stratigraphiques sur les calcaires du Crétacé supérieur et de l'Eocène d'Istrie et des régions voisines. Essai de révision du Liburnien. Trav. Lab. Micropal. 2, Univ. Paris, 6, 1–353, pl. 1–50.

Bubnoff, S. (1956): Einführung in die Erdgeschichte. Akademie-Verlag, Berlin, 1–808, Taf. 1–65.

Hamrla, M. (1960): K razvoju in stratigrafiji produktivnih plasti Primorskega krasa. Rudar.-metalur. zbornik, 3, 203–216.

Haug, É. (1908–1911): Traité de géologie, II. Librairie A. Colin, Paris, p. 1397–2024.

Hötl, M. & R. Pavlovec (1979): Excursion L, Vremski Britof – Vreme beds. 16th Europ. Micropal. Colloquium, Ljubljana, p. 225–228.

Hötl, M. & R. Pavlovec (1981): Vremске plasti kot podlaga danijskim plastem v zahodnih Dinaridih. Simpozij o problemih danija. Zbornik referatov. Odsek za geologijo, Ljubljana, 2, str. 133–136.

Jurkovšek, B., M. Toman, B. Ogorelec, L. Šribar, K. Drobne, M. Poljak & L. Šribar (1996): Formacijska geološka karta južnega dela Tržaško-komenske planote 1: 50.000: Kredne in paleogenske karbonatne kamnine. Inštitut za geologijo, geotehniko in geofiziko, Ljubljana, 145 str.

Knez, M. (1994): Paleoekološke značilnosti vremskih plasti v okolici Škocjanskih jam. Acta Carsol., 23/22, 303–347.

- Pavlovec, R. (1963):** Stratigrafski razvoj starejšega paleogena v južnozahodni Sloveniji. Razprave SAZU 4. razr., 7, 419–556.
- Pavlovec, R. (1968):** Paleogenske plasti v Sloveniji. Prvi kolokvij o geologiji Dinaridov, Ljubljana, 1, 123–127.
- Pavlovec, R. & M. Pleničar (1979):** Cretaceous/Tertiary boundary in the limestone sequence of the West Dinarides. Proceedings Cret.-Tert. Boundary events Symposium. University of Copenhagen, Copenhagen, p. 185.
- Pavlovec, R. & M. Pleničar (1981):** The boundary between Cretaceous and Tertiary in the limestone beds of the West Dinarides. Rudar.-metal. zbornik, 28(1), 25–31.
- Pavlovec, R. & M. Pleničar (1983):** Der ältere Teil der Liburnischen Formation in den NW-Dinariden. Zitteliana, 10, 195–199.
- Pavšič, J. & M. Pleničar (1981):** Danijske plasti v Sloveniji. Simpozij o problemih danija. Zbornik referatov. Odsek za geologijo, Ljubljana, 2, 13–20.
- Pleničar, M. (1961):** Stratigrafski razvoj krednih plasti na južnem Primorskem in Notranjskem. Geologija, 6, 22–145.
- Pleničar, M. (1968):** Kreda v severozahodnih Dinaridih. Prvi kolokvij o geologiji Dinaridov, Ljubljana, 1, 89–95.
- Pleničar, M. (1993):** *Apricardia pachiniana* Sirna from the lower part of Liburnian beds at Divača, Triest-Komen Plateau. Geologija, 35, 65–68.
- Rakovec, I. (1967):** Stache Guido Karel Henrik. Slovenski biografski leksikon, 3(10), 433–434.
- Stache, G. (1859–1867):** Die Eocengebiete in Inner-Krain und Istrien. Jb. geol. R.A., Wien, I: 10, 272–331 (1859); II: 14, 11–115 (1864); III: 17, 243–290 (1867).
- Stache, G. (1872a):** Ueber die Verbreitung der Characeen in den Cosina-Schichten Istriens und Dalmatiens. Verh. geol. R.A., Wien, 115–117.
- Stache, G. (1872b):** Geologische Reisenotizen aus Istrien. Verh. geol. R.A., Wien, 215–223.
- Stache, G. (1872c):** Ueber neue Characeenreste aus der oberen Abteilung der liburnischen Stufe bei Pisino in Istrien. Verh. geol. R.A., Wien, 316–317.
- Stache, G. (1889):** Die Liburnische Stufe und deren Grenz-Horizonte. Abh. Geol. R.A., Wien, 13, 11–170, Taf. 1–8.
- Stache, G. (1920a):** Görz und Gradisca. Geol. Spezialkarte 1:75.000. Geol. Staatsanstalt, Wien.
- Stache, G. (1920b):** Triest. Geol. Spezialkarte 1:75.000. Geol. Staatsanstalt, Wien.

izvirni znanstveni članek
prejeto: 2005-05-03

UDK 612.76:796

UGOTAVLJANJE DEJAVNIKOV, POVEZANIH Z DOSEGANJEM PLATOJA VO_2 PRI TRENIRANIH DEČKIH

Veronika L. KROPEJ

Univerza na Primorskem, Znanstveno-raziskovalno središče Koper, Inštitut za kineziološke raziskave, SI-6000 Koper, Garibaldijska 1
E-mail: Veronika.Kropej@zrs-kp.si

Branko ŠKOF & Radoje MILIČ

Univerza v Ljubljani, Fakulteta za šport, SI-1000 Ljubljana, Gortanova 22

Rado PIŠOT

Univerza na Primorskem, Znanstveno-raziskovalno središče Koper, Inštitut za kineziološke raziskave, SI-6000 Koper, Garibaldijska 1

IZVLEČEK

Doseganje oziroma nedoseganja platoja porabe kisika (VO_2) je še vedno predmet številnih raziskav in študij. Namen te raziskave je 1) primerjati trenirane dečke po doseganju platoja VO_2 , in 2) ugotoviti, kateri antropometrični in fiziološki dejavniki so povezani z doseganjem platoja VO_2 pri treniranih dečkih. V vzorec je bilo vključenih 7 treniranih dečkov (starih $14,9 \pm 0,7$ let, težkih $63,0 \pm 3,7$ kg, visokih $176,8 \pm 5,6$ cm). V povprečju so dosegli vrednosti maksimalne porabe kisika (VO_{2max}) $64,5 \pm 1,6$ ml min⁻¹ kg⁻¹. Štirje dečki od sedmih (57%) so dosegli vse tri kriterije za doseg platoja pri VO_2 . Ugotovili smo, da se izmed vseh antropometričnih in fizioloških dejavnikov, ki so bili vključeni v raziskavo, od drugih loči samo en dejavnik, ki statistično značilno razlikuje skupino dečkov, ki so dosegli plato VO_2 , od skupine dečkov, ki tega platoja niso dosegli, in sicer "trajanje teka na tekoči preprogi", ki se nanaša na test maksimalne aerobne moči. V tem primeru spremenljivka določa, koliko časa je bil vadeči sposoben teči na tekoči preprogi in vzdržati določen napor. V povprečju so dečki, ki niso dosegli platoja, tekli $16,02 \pm 0,79$ min, dečki, ki so dosegli plato, pa $14,88 \pm 0,13$ min. Razlike pri drugih antropometričnih in fizioloških spremenljivkah so bile statistično neznačilne ($P > 0,05$), vendar pa so se rezultati nagibali v korist dečkov, ki niso dosegli platoja VO_2 .

Ključne besede: plato VO_2 , trenirani dečki, antropometrija, fiziološki dejavniki, test na tekoči preprogi, vzdržljivost

RICERCA DI FATTORI COLLEGATI AL RAGGIUNGIMENTO DEL PLATEAU VO_2 IN RAGAZZI ALLENATI

SINTESI

Il raggiungimento ossia il non raggiungimento del plateau del consumo d'ossigeno (VO_2) è ancora al centro di numerose ricerche e studi. Scopo della presente ricerca è quello di confrontare ragazzi allenati dopo il raggiungimento del plateau VO_2 , nonché quello di accertare quali fattori antropometrici e fisiologici sono connessi al raggiungimento del plateau VO_2 in tali ragazzi. Inclusi nell'esperimento sette ragazzi allenati, che in media hanno raggiunto valori massimi di consumo d'ossigeno (VO_{2max}) pari a $64,5 \pm 1,6$ ml min⁻¹ kg⁻¹. Quattro dei sette ragazzi (57%) hanno soddisfatto tutti i criteri necessari al raggiungimento del plateau VO_2 . Gli autori hanno constatato che il gruppo di ragazzi che ha raggiunto il plateau VO_2 differiva dal gruppo di ragazzi che non ha raggiunto il plateau solamente per uno dei fattori inclusi nella ricerca, e cioè per il "tempo di durata della corsa su tappeto scorrevole".

Parole chiave: plateau VO_2 , ragazzi allenati, antropometria, fattori fisiologici, esperimento su tappeto scorrevole, resistenza

UVOD

Kinetika porabe kisika (VO_2) pri nenadni obremenitvi je navadno opisana s pomočjo eksponentne funkcije z relativno strmim naraščanjem na začetku in počasnim asimptotičnim bližanju k platoju. Hamar *et al.* (1991) so natančneje opisali kinetiko VO_2 in analizirali tri faze. Za prvo, ki se začne takoj po začetku obremenitve, je značilna nenadna porast porabe kisika pri prvem ali drugem vdihu, ki mu sledi plato oziroma stabilizacija. Ta faza traja 20 do 25 sekund. Takoj zatem začne poraba kisika eksponentno rasti – kar ponazarja drugo fazo. Ko druga faza doseže vrhunec, preide v tretjo fazo, ki doseže nivo stabilnega stanja porabe kisika, ali pa, če intenzivnost vadbe narašča, doseže anaerobni prag s počasnim preobratom VO_2 navzgor. Ta raziskava se bo osredotočila predvsem na tretjo fazo, to je fazo doseganja oziroma nedoseganja platoja VO_2 .

Pri otrocih in mladostnikih je nivo VO_2 preučevalo veliko predhodnih raziskovalcev in vsi so prišli do različnih deležev tistih, ki so dosegli plato VO_2 in tistih, ki niso. Na primer, Armstrong *et al.* (1995) so odkrili na vzorcu od 111 dečkov (starih $11,1 \pm 0,4$ leta) in 53 deklic (starih $10,9 \pm 0,3$ leta) samo 24% dečkov in 36% deklic, ki so dosegli plato VO_2 . Po drugi strani sta Mahon & Marsh (1993) našla na vzorcu 26 otrok (starih $9,7 \pm 0,8$ leta) 54% otrok, ki so dosegli plato VO_2 . Različni objektivni in subjektivni kriteriji so bili podani za določanje pravega platoja VO_2 . Kriterij platoja je najpomembnejši kriterij pri definiciji maksimalne vrednosti VO_2 , saj so mnogi raziskovalci prepričani, da v primeru, če plato ni opazen, najvišji doseženi VO_2 ni vrednoten kot indikator za otrokovo resnično srčno-dihhalno kapaciteto (Rivera-Brown *et al.*, 2001). $\text{VO}_{2\text{max}}$ je indikator vzdržljivostne kapacitete. Relativna $\text{VO}_{2\text{max}}$ (rel. $\text{VO}_{2\text{max}}$) je največja količina kisika, ki smo jo sposobni porabiti na kg telesne mase v eni minuti.

Raziskovalci so v svojih študijah uporabili različne metode in kriterije za določanje $\text{VO}_{2\text{max}}$, kar je gotovo eden izmed razlogov za različna odkritja v njihovih študijah. Tako je na primer raziskava Kemperja & Zunderta (1991) za kriterij doseganja platoja VO_2 določila, da se ne sme v zadnji minuti vadbe VO_2 povečati za več kot 150 ml, srčni utrip (HR [ud min^{-1}]) mora biti vsaj 95% prilagojen letom, respiratorni kvocient (RER) pa mora preseči vrednost 1 med vadbo. RER je razmerje med volumnom izdihanega CO_2 na minuto in volumnom porabljenega O_2 na minuto (VCO_2/VO_2). Pri naporu nad anaerobnim pragom RER preseže vrednost 1, toda normalno nikoli ne preseže vrednosti 1,25, kljub maksimalnim človeškim naporom (Bullock *et al.*, 1995). Paterson *et al.* (1981) so vzeli za kriterij povečanje VO_2 za manj kot $2,1 \text{ ml min}^{-1} \text{ kg}^{-1}$ v zadnji minuti vadbe s povečevanjem napora (vadba je trajala do izčrpanosti posameznika). Nevill *et al.* (1998) so določili, da mora biti HR večji od 95%, RER mora biti večji od 1,1 in po-

večanje VO_2 za manj kot $2 \text{ ml min}^{-1} \text{ kg}^{-1}$ v zadnji minuti vadbe s povečevanjem napora. Vse študije so imele isti namen: določiti, zakaj nekateri otroci dosežejo plato VO_2 , drugi pa ne. Nekateri avtorji so prepričani, da ni razlik med tistimi, ki dosežejo plato VO_2 , in tistimi, ki ga ne. Na primer, Rivera-Brown *et al.* (2001) so primerjali maksimalno in povprečno anaerobno moč pri predpubertetnih otrocih, ki so dosegli plato s tistimi, ki ga niso, in niso našli razlik. Po drugi strani so drugi poročali o statistično značilnih razlikah. Ritmeester *et al.* (1985) so odkrili, da so imeli otroci, ki so dosegli plato VO_2 , nižji $\text{VO}_{2\text{max}}$ kot tisti, ki niso dosegli platoja. Kemper & van Zundert (1991), ki sta se osredotočila na antropometrične razlike med otroki, ki so, in takimi, ki niso dosegli platoja VO_2 med maksimalno obremenitvijo na tekoči preprogi, sta poročala, da je večja mišična masa na nogi vodila do relativno višje $\text{VO}_{2\text{max}}$, ne da bi prišlo do platoja porabe kisika. Borrani *et al.* (2001) poudarjajo, da mehanizmi za razlago platoja pri VO_2 niso povsem pojasnjeni. V svoji študiji so se osredotočili predvsem na t.i. VO_2 – počasno komponento, ki ponazarja porast VO_2 med visoko-intenzivno vadbo pri konstantni obremenitvi. Namigujejo, da je eden od razlogov za pojav VO_2 počasne komponente lahko rekrutacija hitrih mišičnih vlaken, ki naj bi kompenzirale primanjkljaj počasnih mišičnih vlaken. Niesen-Vertommen *et al.* (1995) so merili na otrocih $\text{VO}_{2\text{max}}$ maksimalno moč in povprečno moč na sobnem kolesu in odkrili višjo anaerobno moč pri tistih otrocih, ki so dosegli plato. Tudi Duncan *et al.* (1996), ki so merili $\text{VO}_{2\text{max}}$ na dečkih na tekoči preprogi, so ugotovili, da tisti dečki, ki so dosegli plato, kažejo višje vrednosti pri anaerobni moči in kapaciteti in drugih kazalcih anaerobnih sposobnosti, kot tisti, ki platoja niso dosegli. Težko je enotno odgovoriti na to, kaj je povezano z doseganjem platoja VO_2 pri otrocih.

Namen te raziskave je 1) primerjati trenirane dečke po doseganju platoja VO_2 , in 2) ugotoviti, kateri antropometrični in fiziološki dejavniki so povezani z doseganjem platoja VO_2 pri treniranih dečkih. Na podlagi teh ugotovitev bomo lahko sklepali, po katerih spremembah se dečki, ki so dosegli plato, razlikujejo od dečkov, ki niso dosegli platoja.

MATERIAL IN METODE

Merjenci

V analizo je bilo vključenih 7 treniranih dečkov, ki v povprečju 5 let trenirajo teke na srednje proge tj. tek na 800 m, 1000 m in 1500 m. V povprečju so bili stari $14,9 \pm 0,7$ let, teži $63,0 \pm 3,7$ kg, visoki $176,8 \pm 5,6$ cm. Njihova povprečna vrednost maksimalne porabe kisika ($\text{VO}_{2\text{max}}$) je bila $64,5 \pm 1,6 \text{ ml min}^{-1} \text{ kg}^{-1}$. Za primerjavo lahko navedemo, da so netrenirani dečki dosegli povprečno vrednost $\text{VO}_{2\text{max}}$ $50,8 \pm 5,9 \text{ ml min}^{-1} \text{ kg}^{-1}$ (Kropej *et al.*, 2005).

Eksperimentalni postopek

Pred začetkom meritev so bili otroci natančno seznanjeni s testnimi nalogami in inštrumenti. Eksperimentalni postopek je bil razdeljen na 2 merilna dneva. V prvem je bilo opravljeno merjenje časa teka na 20 metrov z letečim štartom, test eksplozivne moči in izmerjene so bile antropometrične značilnosti. V drugem je bil napravljen test maksimalne aerobne moči. Med prvim in drugim merjenjem je minilo 3 do 5 dni.

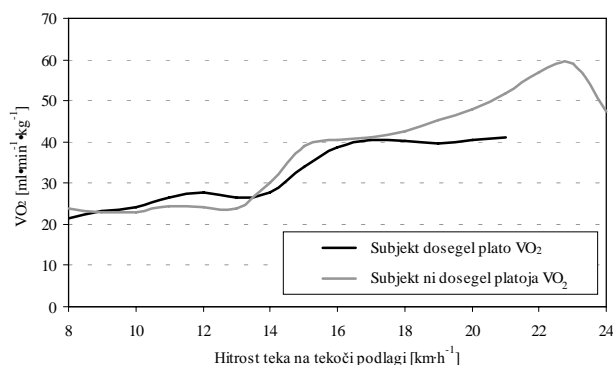
Protokol

Test maksimalne aerobne moči se je opravljal na tekoči preprogi. Otroci so opravljali večstopenjski obremenilni test, pri čemer se je hitrost povečevala vsako minuto pri stalnem 5% naklonu tekoče preproge. Začetna hitrost je bila 8 km h^{-1} . Hitrost je naraščala vsako minuto za 1 km h^{-1} do lastne izčrpanosti. Pred testom so se otroci 11 minut ogrevali pri 6 do 8 km h^{-1} brez naklona. Test so preiskovanci opravljali s prenosno "breath by breath" telemetrijsko enoto K4b Cosmed (Italija), s katero je bila izmerjena ventilacija (Ve [l]) je volumen zraka, ki ga vdihamo ali izdihamo), največja relativna poraba kisika (rel. $\text{VO}_{2\text{max}}$) in respiratorni kvocient (RER). Prednost prenosne telemetrijske naprave je v tem, da zaradi lahke uporabe (maska na obrazu meri izmenjavo plinov) in nizke teže (tehta samo 600g) omogoča opravljanje meritev med samo aktivnostjo na katerem koli terenu oziroma v situacijskem okolju kot tudi po standardnih protokolih v laboratoriju. Frekvenca srčnega utripa (HR) je bila merjena z merilniki srčnega utripa Polar in telemetrijsko enoto Polar (Oulu, Finska).

Čas teka na 20 m z letečim štartom je bil izmerjen z napravo Brower Timing System (USA). Merjenci so imeli pred merjenjem 10-20 m pospeševalne cone.

Vertikalni skok iz pol-čepa in skok z nasprotnim gibanjem sta bila merjena na tenziometrični plošči Kistler, 9278 Winterthur (Švica) v laboratoriju. Višina skoka je bila izračunana iz časa leta. Pri skoku iz pol-čepa je subjekt napravil vertikalni skok iz pol-čepa (kot v kolenu je 90°), hrbet je imel izravnane in obe roki v bokih. Merjenec je opravil test brez nasprotnega gibanja. Pri skoku z nasprotnim gibanjem je merjenec štartal iz vzravnanne pozicije z rokami v boku, izvedel gibanje navzdol (po koncu nasprotnega gibanja je kot v kolenu 90°) in napravil vertikalni skok.

Iz antropometričnih meritev je bilo vsakemu otroku izračunana masa mišičnega in maščobnega tkiva v kilogramih ter pretvorjena v deleže. Relativni delež maščobnega in mišičnega tkiva je bil izračunan na podlagi metode po Matiegki (1921).



Sl. 1: Primer kinetike VO_2 .

Fig. 1: An example of VO_2 kinetics.

Kriteriji za doseganje platoja VO_2 so bili povzeti po študiji Rivera-Brown *et al.* (2001) ter Karila *et al.* (2001) in so bili enaki kot pri raziskavi doseganja platoja pri VO_2 pri netreniranih otrocih (Kropej *et al.*, 2002). Otrok je dosegel plato VO_2 , če so bili izpolnjeni naslednji kriteriji: 1) $\text{RER} \geq 1,0$; 2) $\text{HR} \geq 90\%$ maksimalnega ($220 - \text{starost otroka}$), in 3) sprememba VO_2 v zadnji minuti vadbe $\leq 2 \text{ ml min}^{-1} \text{ kg}^{-1}$ s povečevanjem napora. Primer kinetike VO_2 pri subjektu, ki je dosegel plato VO_2 , in subjektu, ki platoja ni dosegel, je prikazan na sliki 1.

Statistična analiza

Izračunali smo delež dečkov, ki dosegajo vse kriterije za plato VO_2 , ter povprečne vrednosti in standardne odklone za vse spremenljivke. Za ugotavljanje razlik v antropometričnih in fizioloških dejavnikih med dečki, ki so dosegli plato, in tistimi, ki ga niso, smo uporabili neparametrični Mann-Whitneyev U test kot alternativni test t -testu za neodvisna vzorca. Nivo statistične značilnosti ocene parametra (α napaka) je znašal 0,05.

REZULTATI

Doseganje kriterijev za plato VO_2

Prvi kriterij ($\text{RER} \geq 1,0$) je izpolnilo vseh 7 dečkov. Drugi kriterij ($\text{HR} \geq 90\%$) je izpolnilo 6 dečkov (86%). Tretji kriterij ($\Delta\text{VO}_2 \leq 2 \text{ ml min}^{-1} \text{ kg}^{-1}$) pa je izpolnilo 5 dečkov (71%). Za doseganje platoja VO_2 so morali biti izpolnjeni vsi trije kriteriji; dosegli so ga štirje dečki.

Primerjava dečkov, ki so dosegli plato VO_2 , s tistimi, ki ga niso

Statistično značilne razlike ($P < 0,05$) med dečki, ki so dosegli plato, in tistimi, ki ga niso, je določena pri spremenljivki *trajanje teka na tekoči preprogi*, ki se nanaša na test maksimalne aerobne moči. V tem pri-

meru spremenljivka določa, koliko časa je bil vadeči sposoben vzdržati določen napor. Štirje dečki od sedmih (57%) so izpolnili vse tri kriterije za doseg platoja VO₂. V Tabeli 1 so prikazani rezultati analize doseganja platoja VO₂ za trenirane dečke.

Analiza doseganja platoja VO₂ pri treniranih dečkih je pokazala, da se tisti, ki dosegajo plato VO₂, in tisti, ki ga ne dosegajo, statistično značilno razlikujejo le v spremenljivki *trajanje teka na tekoči preprogi*. To ni presenetljivo, saj je vzorec majhen, vsi trenirajo v enakih razmerah in sestavljajo homogeno skupino. Kljub temu je opazna razlika med skupinama.

Tab. 1: Povzetek rezultatov raziskave doseganja platoja VO₂ pri treniranih dečkih (povprečne vrednosti spremenljivke ± standardni odklon).

Tab. 1: Summary of the results obtained while studying trained boys in achieving the VO₂ plateau (average variable values ± standard deviation).

	Plato (n = 4)	Brez platoja (n = 3)	U-test* (P)
Starost (leta)	14,75 ± 0,50	15,00 ± 1,00	0,69
Višina (cm)	177,00 ± 4,83	176,67 ± 7,77	0,99
Teža (kg)	61,75 ± 4,11	64,67 ± 3,06	0,29
HRmax (ud·min ⁻¹)	198,00 ± 4,76	205,00 ± 9,85	0,28
VO _{2max} (ml·min ⁻¹ ·kg ⁻¹)	63,93 ± 1,76	65,33 ± 1,17	0,29
RERmax	1,09 ± 0,029	1,04 ± 0,04	0,29
Ve (l·min ⁻¹)	134,56 ± 10,01	155,17 ± 15,61	0,16
Trajanje teka na tekoči preprogi (min)	14,88 ± 0,13	16,02 ± 0,79	0,03
Vertikalni skok iz polčepa (cm)	34,01 ± 6,12	37,21 ± 6,02	0,48
Vertikalni skok z nasprotnim gibanjem (cm)	37,09 ± 4,25	39,54 ± 5,21	0,48
Delež maščobnega tkiva (%)	8,40 ± 0,98	7,57 ± 0,31	0,29
Delež mišičnega tkiva (%)	51,73 ± 0,37	53,57 ± 2,91	0,48
Debelina kožne gube na stegnu (mm)	7,40 ± 1,94	6,00 ± 0,20	0,15
Debelina kožne gube nadlahti (mm)	5,70 ± 1,99	5,40 ± 0,53	0,48
Čas teka na 20 m z letečim štartom (s)	2,37 ± 0,07	2,27 ± 0,06	0,13

* točna stopnja značilnosti testiranja razlik med aritmetičnima sredinama pri dveh neodvisnih vzorcih

Rezultati iz zgornje tabele nakazujejo "prednost" dečkov brez platoja VO₂ pred tistimi, ki so dosegli ta plato. V vseh navedenih spremenljivkah imajo dečki brez platoja namreč boljši rezultat. To se kaže predvsem v naslednjih treh spremenljivkah: *ventilaciji* (Ve): merjenci, ki so dosegli plato VO_{2max}, imajo v povprečju nižjo ventilacijo (134,53 l min⁻¹) od merjencev, ki omenjenega platoja niso dosegli (155,17 l min⁻¹); *kožni gubi na stegnu*: merjenci, ki so dosegli plato VO_{2max}, imajo v povprečju večjo kožno gubo na stegnu (7,40 mm) od merjencev, ki

omenjenega platoja niso dosegli (6,00 mm); *času teka na 20 metrov z letečim štartom*: merjenci, ki so dosegli plato VO_{2max}, imajo v povprečju slabši rezultat pri teku na 20 metrov z letečim štartom (2,37 s) od merjencev, ki omenjenega platoja niso dosegli (2,27 s).

RAZPRAVA

Statistično značilno razliko (P < 0,05) med dečki, ki so dosegli plato, in tistimi, ki ga niso, smo ugotovili pri spremenljivki *trajanje teka na tekoči preprogi*, ki se nanaša na test maksimalne aerobne moči. Dečki brez platoja vzdržijo obremenitev v povprečju za dve minuti dlje. Pri drugih spremenljivkah ni statistično značilnih razlik. Glavni razlog je verjetno v majhnosti vzorca in v trenajnem procesu, ki je za vse enak.

Analiza naše študije na treniranih dečkih je pokazala, da je doseglo plato 57% dečkov. Pri treniranih je VO_{2max} večja pri dečkih, ki ne dosegajo platoja. To ugotovitev potrjuje tudi študija Ritmeestra in sodelavcev (1985), ki je odkril, da imajo otroci, ki dosegajo plato VO₂, nižjo VO_{2max} kot tisti, ki platoja ne dosegajo. Podobne so bile tudi ugotovitve analize doseganja platoja pri netreniranih otrocih. Pri netreniranih je plato VO₂ doseglo 56% otrok, in tudi pri tistih, ki so dosegli plato, je bila opažena nižja VO_{2max} (Kropej *et al.*, 2002).

Vse te ugotovitve nakazujejo, da so dečki, ki ne dosegajo platoja v boljši telesni pripravljenosti oziroma kondiciji kot dečki, ki dosegajo plato. Kljub vsemu pa so znotraj skupine razlike, ki natančno kažejo razlike med dečki, ki dosegajo plato, in tistimi, ki ga ne dosegajo. Povprečna VO_{2max} pri dečkih s platojem je 63,9 ml min⁻¹ kg⁻¹, pri dečkih brez platoja pa 65,3 ml min⁻¹ kg⁻¹. Rowland (1996) je mnenja, da maščobno tkivo znižuje relativno VO₂, saj so subjekti z manj maščobnega tkiva in z večjo mišično maso fizično zmogljivejši in sposobni dalj časa teči pri VO_{2max}. V naši raziskavi imajo dečki, ki so dosegli plato, višji delež maščobnega tkiva v primerjavi s tistimi, ki platoja niso dosegli. Kemper & van Zundert (1991) sta prišla do podobnih ugotovitev, in sicer, da je razlika med otroki, ki dosegajo plato, in tistimi, ki ga ne dosegajo, povezana z določenimi antropometričnimi značilnostmi in mišično maso. Ugotovila sta, da več mišičnega tkiva na nogi vodi do večje VO_{2max} brez doseganja platoja VO₂. To ugotovitev sta povezala s spolom in ugotovila, da dekleta, ki imajo manjši delež mišičnega tkiva, v večji meri dosegajo plato VO₂ kot fantje. Še več, 5 let po prvem testiranju (pri starosti 20 let) so se razlike še povečale. Postavlja pa se vprašanje, kaj bi bilo, če bi VO_{2max} izrazili relativno glede na nemastno maso. Ali bi se tudi v tem primeru izrazile spremembe med merjenci, ki dosegajo plato, in tistimi, ki ga ne?

Carra *et al.* (2003) so v svoji raziskavi ugotovili, da imajo merjenci, ki so presegli plato, povečano ventilacijo. Ta vodi do povečanega mehanskega dela dihalnih mišic in posledično do povečane zahteve po kisiku v

teh mišicah. Borrani *et al.* (2001) so mnenja, da je pojav počasne komponente lahko povezan z rekrutacijo hitrih mišičnih vlaken, potem ko se storilnost počasnih vlaken zniža. Poudarjajo, da je pri submaksimalnem naporu že dokazano, da se najprej rekrutirajo počasna mišična vlakna, pri visoko intenzivnem naporu, kjer se zniža pH, neorganski fosfat poveča in da pride do akumulacije kalija. Mnenja so, da morajo te metabolične modifikacije privedi do rekrutacije drugih mišičnih vlaken, v katere vključujejo tudi hitra mišična vlakna. Menimo, da je delež počasnih ali hitrih vlaken, ki se bo rekrutiral, odvisen od same mišice, kajti na primer mišica soleus ima večji delež počasnih mišičnih vlaken.

Sklepamo, da so otroci z več maščobnega tkiva in nižjo VO_{2max} (slabša aerobna moč) prišli do platoja VO₂ hitreje, ker so se prej utrudili. Otroci, ki so dosegli plato VO₂, niso bili sposobni zdržati zahtevane intenzivnosti, zato je bil njihov čas do izčrpanosti krajši. To dokazuje parameter *trajanje teka na tekoči preprogi*, saj so dečki s platojem manj časa vzdržali obremenitev. Demarle *et al.* (2001) so mnenja, da je zaradi pospešenega srčnega utripa in povečanega udarnega volumna mogoče sklepati, da je prenos kisika do aktivne mišice izboljšán že na začetku vadbe, zaradi česar lahko posameznik preseže plato. Vse te značilnosti se kažejo v rezultatih pri testih največje aerobne zmogljivosti. Zaključili so, da je kisikov primanjkljaj povezan s povečanjem časa do izčrpanosti pri intenzivnem teku, ki je opravljen po specifičnem vzdržljivostnem programu treniranja. Po drugi strani pa ugotavljamo, da so osebe z nasprotnimi značilnostmi (večja mišična masa, boljši prenos kisika, višja VO_{2max}, daljši čas do izčrpanosti) tudi lahko dosegle plato VO₂, toda ker še niso prišle do faze izčrpanosti, so lahko nadaljevale vadbo nad nivo platoja VO₂, dokler niso dosegle svojega pravega VO_{2max}.

ZAKLJUČEK

Namen te raziskave je bil primerjati trenirane dečke po doseganju platoja VO₂ in ugotoviti, kateri antropometrični in fiziološki dejavniki so povezani z doseganjem platoja VO₂ pri treniranih dečkih. Vprašanje, ki smo si ga zastavili, je bilo, zakaj nekateri dečki dosegajo plato, drugi pa ga ne dosežejo oziroma presežejo, čeprav so deležni enakega procesa treniranja. Ugotovili smo, da so razlike minimalne (samo v spremenljivki *trajanje teka na tekoči preprogi* so razlike statistično značilne), kar bi verjetno lahko pripisali majhnosti vzorca. Pri vseh naštetih spremenljivkah se rezultati nagibajo v korist dečkov, ki platoja niso dosegli oziroma so ga presegle. Zato smo mnenja, da je na osnovi dobljenih rezultatov težko sklepati, zakaj eni dosežejo plato in se prej utrudijo, drugi pa ga presežejo in so telesno sposobnejši. Gotovo imajo določen vpliv na to tudi drugi dejavniki (razvojne razlike, genetika, izkušensko bogato okolje), ki pa jih v naši raziskavi nismo spremljali in so možna izhodišča naslednjih raziskav.

Glavna ugotovitev te raziskave je, da se izmed vseh antropometričnih in fizioloških dejavnikov, ki so bili vključeni v raziskavo, od drugih loči samo en dejavnik, ki statistično značilno razlikuje skupino dečkov, ki so dosegli plato VO₂ (teh je bilo 57%), od skupine dečkov, ki niso dosegli platoja VO₂. Ta dejavnik je *trajanje teka na tekoči preprogi* in se nanaša na test maksimalne aerobne moči. V povprečju so dečki, ki niso dosegli platoja, tekli 16,02 ± 0,79 min, dečki, ki so dosegli plato, pa 14,88 ± 0,13 min. Razlike pri drugih antropometričnih in fizioloških spremenljivkah so bile statistično neznailne ($P > 0,05$), vendar so se rezultati nagibali v korist dečkov, ki niso dosegli platoja VO₂.

THE FACTORS ASSOCIATED WITH ACHIEVEMENT OF VO₂ PLATEAU IN TRAINED BOYS

Veronika L. KROPEJ

University of Primorska, Science and Research Centre of Koper, Institute of Kinesiology Research, SI-6000 Koper, Garibaldijeva 1
E-mail: Veronika.Kropej@zrs-kp.si

Branko ŠKOF & Radoje MILIČ

University of Ljubljana, Faculty of Sport, SI-1000 Ljubljana, Gortanova 22

Rado PIŠOT

University of Primorska, Science and Research Centre of Koper, Institute of Kinesiology Research, SI-6000 Koper, Garibaldijeva 1

SUMMARY

Many researchers have investigated the achieving and non-achieving the oxygen consumption (VO₂) plateau. The purpose of this research was 1) to compare trained boys who achieve the plateau, with those who do not, and 2) to determine which anthropometric and physiological factors influence the achievement of VO₂ plateau in trained boys. The sample comprised 7 trained boys (age 14.9 ± 0.7 yrs, weight 63.0 ± 3.7 kg, height 176.8 ± 5.6 cm). The

boys exhibited average VO_{2max} values of $64.5 \pm 1.6 \text{ ml min}^{-1} \text{ kg}^{-1}$ during the exercise. The criteria for achieving the plateau were respiratory exchange rate greater or equal to 1.0, heart rate greater or equal to 90 % of the predicted age-adjusted maximal heart rate, and the change in VO_2 in the last minute of exercise less or equal to $2 \text{ ml min}^{-1} \text{ kg}^{-1}$ with an increase in workload. Four boys (out of seven) (57%) met all three criteria for achieving the plateau in VO_2 . We found there was only one physiological factor, from all anthropometric and physiological factors that were included in this research, which drew a distinction between boys who achieved a plateau in VO_2 and those who did not. This factor is the "duration of the treadmill test", which relates to the test of maximal aerobic power. In this case the variable determines how long the subject is capable to run on a treadmill and to sustain defined effort. On average, boys who did not achieve a plateau ran $16.02 \pm 0.79 \text{ min}$ and boys who achieved a plateau ran $14.88 \pm 0.13 \text{ min}$. Differences in all others variables were not statistically significant (an alpha level of $P < 0.05$ was considered significant), although all the obtained results were more in favour of the boys who did not achieve a plateau in VO_2 .

Key words: VO_2 plateau, trained boys, anthropometry, physiological factors, treadmill test, endurance performance

LITERATURA

- Armstrong, N., B. J. Kirbi, A. M. McManus & J. R. Welsman (1995):** Aerobic fitness of prepubescent children. *Ann. Hum. Biol.*, 23(2), p. 188.
- Borroni, F., R. Candau, G. Y. Millet, S. Perrey, J. Fauchslöcher & J. D. Rouillon (2001):** Is the VO_2 slow component dependent on progressive recruitment of fast-twitch fibers in trained runners? *J. Appl. Phys.*, 90, 2212–2220.
- Bullock, J., J. Boyle & M. B. Wang (1995):** Physiology. 3rd Edition. Williams & Wilkins, Malvern, PA.
- Carra, J., R. Candau, S. Keslacy, F. Giolbas, F. Borroni, G. P. Millet, A. Varray & M. Ramonatxo (2003):** Addition of inspiratory resistance increases the amplitude of the slow component of O_2 uptake kinetics. *J. Appl. Phys.*, 94, 2448–2455.
- Demarle, A. P., J. J. Slawinski, L. P. Laffite, V. G. Bocquet, J. P. Koralzstein & V. L. Billat (2001):** Decrease of O_2 deficit is a potential factor in increased time to exhaustion after specific endurance training. *J. Appl. Phys.*, 90(3), 947–53.
- Duncan, G. E., A. D. Mahon, C. A. Howe & P. Del Corral (1996):** Plateau in oxygen uptake at maximal exercise in male children. *Ped. Exer. Sci.*, 8, 77–86.
- Hamar, D., M. Tkac, L. Komadesl & O. Kuthanova (1991):** Oxygen uptake kinetics at various intensities of exercise on the treadmill in young athletes. *Ped. W. Phys.*, 15, 187–200.
- Karila, C., J. de Blic, S. Waernessyckle, M. R. Benoist & P. Scheinmann (2001):** Cardiopulmonary exercise testing in children. *Chest*, 120, 81–87.
- Kemper, H. C. G. & A. van Zundert (1991):** Role of leg muscle mass in reaching a levelling-off in oxygen uptake during maximal treadmill running in male and female adolescents. In: Frenkl, R. & I. Szmodis (eds): *Children and Exercise*. *Ped. W. Phys.*, p. 65–73.
- Kropej, V. L., B. Škof & R. Milič (2002):** Achievement of VO_2 plateau in children. 3rd Int. Sci. Conf. "Kinesiology – new perspectives", Opatija, Croatia. Faculty of kinesiology, University of Zagreb, Zagreb, p. 511–514.
- Kropej, V. L., B. Škof & R. Milič (2005):** The influence of aerobic and anaerobic characteristics of children of different age on achievement of VO_2 plateau. *Biol. Sport*, 22(1), 67–79.
- Mahon, A. D. & M. L. Marsh (1993):** Ventilatory threshold and VO_2 plateau at maximal exercise in 8- to 11-year old children. *Ped. Exer. Sci.*, 5, 332–38.
- Matiegka, J. (1921):** The testing of physical efficiency. *Am. J. Phys. Anthropol.*, 4, 223–230.
- Nevill, A. M., R. L. Holder, A. Baxter-Jones, J. M. Round & D. A. Jones (1998):** Modeling developmental changes in strength and aerobic power in children. *J. Appl. Phys.*, 84(3), 963–70.
- Niesen-Vartommen, S., D. C. McKenzie, D. K. Jespersen & S. P. D. Tumer (1995):** Anaerobic power measurement and VO_2 plateau in children. *Med. Sci. Sports Exer.*, 27, S14.
- Paterson, D. H., D. A. Cunningham & A. Donner (1981):** The effect of different treadmill speeds on the variability of VO_{2max} in children. *Eur. J. Appl. Phys.*, 47, 113–22.
- Ritmeester, J. W., H. C. G. Kemper & R. Verschuur (1985):** Is a levelling-off criterion in oxygen uptake a prerequisite for a maximal performance in teenagers? In: Binkhorst, R. A., H. C. G. Kemper & W. H. M. Saris (eds.): *Children and Exercise XI*. *Hum Kin*, p. 161–169.
- Rivera-Brown, A. M., M. Alvarez, J. R. Rodriguez-Santana & P. J. Benetti (2001):** Anaerobic power and achievement of VO_2 plateau pre-pubertal boys. *Int. J. Sports Med.*, 22, 111–115.
- Rowland, T. W. (1996):** Exercise testing. In: Rowland, T. W. (ed.): *Developmental exercise physiology*. *Hum Kin*, 27–47.

**POROČILA
RELAZIONI
REPORTS**

**SAME 9 – 9. SIMPOZIJ MIKROBNE EKOLOGIJE
(SYMPOSIUM ON AQUATIC MICROBIAL ECOLOGY –
SAME)**

Med 21. in 26. avgustom 2005 je na Finskem potekal 9. simpozij mikrobne ekologije vodnih sistemov (Symposium on Aquatic Microbial Ecology – SAME). Prvi simpozij mikrobne ekologije European Marine Microbial Symposium (EMMS) je bil organiziran pred 18 leti. V naslednjih letih se je EMMS zaradi velikega zanimanja in vključitve mikrobiologov drugih kontinentov v mednarodni organizacijski odbor povezal z organizatorji konference Merjenja mikrobne aktivnosti in kroženja snovi v vodnih ekosistemih (International workshop on the Measurement of Microbial Activities in the Cycling of Matter in Aquatic Environments) in preimenoval v SAME.

Letos je simpozij potekal na Univerzi v Helsinkih, v samem središču mesta na Senatnem trgu in v neposredni bližini pristaniškega dela Kruununhaka. Car Nicholas je leta 1827, po velikem požaru v takratnem glavnem mestu Turku, ukazal Kraljevi akademiji, da univerzo premesti v novo nastajajoče mesto. Univerza s knjižnico je bila v neo-klasicističnem slogu zgrajena v letih 1828/29 v središču mesta. Univerza ima danes kakih 20.000 študentov ter 3000 pedagoških delavcev in raziskovalcev.

Simpozija se je udeležilo 250 raziskovalcev, predvsem iz Evrope in Amerike, posamezno pa tudi iz Braziliije, Irana, Japonske, Malezije, Nove Zelandije in Tajske. Predavanja so namenoma potekala samo v eni sekciji s skrbno izbranimi plenarnimi in posameznimi predstavami ter z obsežno predstavitvijo posterjev ves čas simpozija. Pregledna predavanja najnovejših rezultatov in raziskav so bila razporejena v naslednje tematske sklope: vloga mikrobov v biogeokemičnih procesih, molekularna struktura združb, ekološki pomen biodiverzitete, regulacija mikrobne združbe, mikrobi ekstremnih habitatov, biofilmi in uporaba novih tehnologij v mikrobni ekologiji.

Vlogo bakterij v morju je prvi obsežno opisal Claude Zobell že leta 1940 v knjigi Marine Microbiology. Kljub temu sta se zanimanje in obseg raziskav na tem področju razširila šele v sedemdesetih in osemdesetih letih z uporabo novih tehnik epifluorescentne mikroskopije in uporabe radioaktivno označenih spojin za meritve hitrosti rasti združb mikroorganizmov, predacijskih hitrosti ali meritev metabolnih poti. Številna nova spoznanja o vlogi avtotrofnih in heterotrofnih mikroorganizmov v morjih in drugih vodnih ekosistemih so pripeljala do sprememb klasičnih teorij in povezovanja mikrobov v modele kroženja snovi v ekosistemih.

Druge pomembno obdobje mikrobne ekologije je

obdobje raziskav populacij mikroorganizmov znotraj posameznih združb. Nove tehnike molekularne biologije in genetike omogočajo določanje dominantnih skupin bakterij, arhej, njihovo razširjenost in sezonske sukcesije. Na simpoziju so bili prikazani rezultati raziskav mikrobne biodiverzitete različnih morskih in oceanskih ekosistemov, visokogorskih jezer, rečnih habitatov, akumulacij, estuarijev in ekstremnih habitatov, kot so globoka oceanska območja Severnega Atlantika, Črno morje, območja ekstremnih slanosti in večnega ledu. Z uporabo molekularnih metod se je v zadnjih 25 letih v javni bazi GenBank zbralo več kot 7070 nukleotidnih sekvenc izoliranih prokariotov. Natančne analize sekvenc 16S rDNA za morske planktonske bakterije kažejo razmeroma nizko vrstno sestavo (zapisi 2382 "ribotipskih vrst" bakterioplanktona). Na osnovi geografskih informacij vsake opisane sekvence je ugotovljeno, da polovica klonov pripada vrstam, ki so vsesplošno razširjene, polovica pa endemičnim vrstam, specifičnim za posamezne regije. Prevladujejo oportunistične vrste, vendar analize sezonske sukcesije kažejo različne letne razporeditve dominantnih skupin. Večino bakterij še vedno ne moremo gojiti, kar je svojevrsten izziv za morske mikrobiologe. Znan je primer bakterije SAR 11, za katero dolgo niso verjeli, da je bakterija. Izolirali so jo v Sargaškem morju in jo zdaj tudi gojijo v ultraoligotrofnih razmerah. Raziskave na celičnem nivoju so pokazale, da kolonije razvijejo le vrste, ki imajo kontrolni regulatorni mehanizem za prepoznavanje signala o pojavljanju organizma iste vrste v okolju ("quorum sensing"). Mikrobna ekologija vsekakor prehaja v obdobje raziskav na celičnem nivoju, interakcij posameznega organizma z drugimi in odzivi organizma na spremembe okolja. Razmeroma preprosta uporaba tehnik molekularne biologije omogoča raziskave vloge posameznih genov, prepoznavanja molekul in signalov, pomembnih v procesih, kot je npr. fagotrofija praživali. Nove tehnologije omogočajo tudi uporabo številnih mikroskopskih tehnik, avtoradiografije ali pretočne citometrije v kombinaciji z metodami filogenetske identifikacije. Široko uporabo dobiva metoda fluorescentne hibridizacije *in situ* in mikroautoradiografije za določanje aktivnosti na nivoju posameznih skupin bakterij (MICRO-FISH, CARD-FISH). Raziskave funkcionalne raznolikosti in vloge mikroorganizmov so pomembne pri preučevanju kompleksnih ekoloških problemov, vplivu klimatskih sprememb na biogeokemične spremembe v ekosistemu in s tem povezane sociološke in ekonomske spremembe.

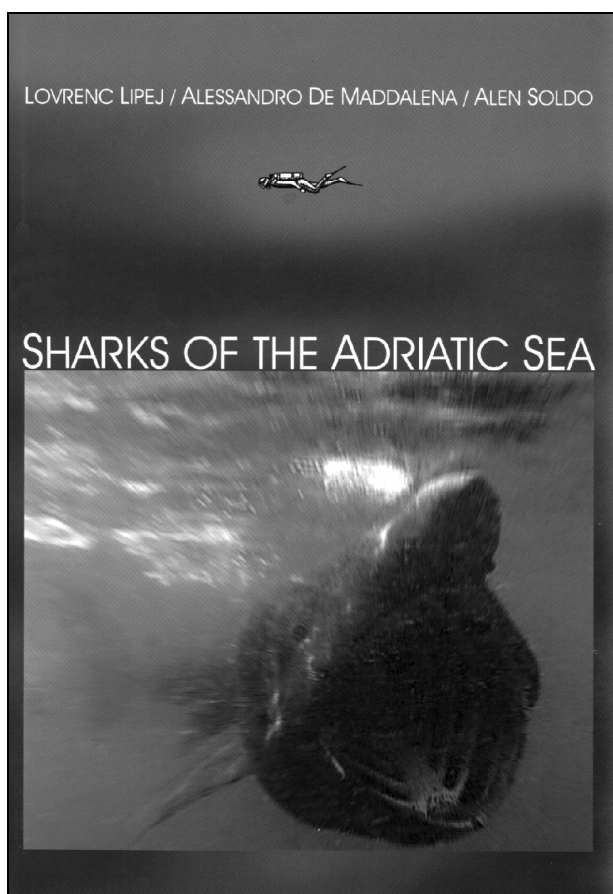
Družabni del srečanja je omogočal še dodatne razprave in navezovanje sodelovanj ob sprejemu rektorja univerze in župana v mestni hiši, skupni večerji in ogledu 250 let stare utrdbe Suomenlinna na otoku pred mestom. Naslednje srečanje je predvideno na Portugalskem leta 2007.

Valentina Turk

**OCENE
RECENSIONI
REVIEWS**

Lovrenc LIPEJ, Alessandro DE MADDALENA
and Alen SOLDI: *SHARKS OF THE ADRIATIC SEA*
Knjižnica Annales Majora, Univerza na Primorskem,
Znanstveno-raziskovalno središče, Koper, 2004, 253 pp.

After many years of study, investigation and data collecting, three Mediterranean researchers, Lovrenc Lipelj from the Marine Biology Station of Piran, Alessandro De Maddalena from the Italian Ichthyological Society and one of founding members of the Mediterranean Shark Research Group, and Alen Soldo from the Laboratory of Ichthyology and Coastal Fishery of the Institute of Oceanography and Fisheries of Split, have put their great knowledge of sharks together and published a new book: *Sharks of the Adriatic Sea*. Apart from being a very ambitious project, the work is certainly a highly comprehensive guide.



It is a book long waited for by the scientific community that analyzes, with the aid of current and recent data, the present species in the Adriatic Sea. The work is of interest and extremely practical for shark specialists, as comprehensive, precise and updated information can be found in it. The 253 pages of the book include parts dealing with oceanography of the area, generalities on the biology and ecology of sharks, the key to identification and full description of the 28 species occurring in the Adriatic Sea. There are also two very interesting sections dedicated to the status of sharks in the Adriatic Sea and shark research in the area. The book ends with section dedicated to sharks with doubtful status and extensive bibliography. The records of shark species, excellently illustrated by Alessandro De Maddalena, include sections on morphology, reproduction, diet, habitat, distribution, behaviour, dangerousness, status and extensive references. Let us also highlight the final annex that includes colour as well as black and white pictures on the biology and the present species in the area. The book, a must for all those who wish to get better acquainted with the sharks of the Adriatic Sea as well as those of the Mediterranean Sea, is presented in a practical soft cover 17 x 24 cm format, it is well designed and printed on high quality paper.

Congratulations to the authors and the editors of this book, which will highly enrich the existent although very scarce bibliography on such exciting and hard to study topic as is the knowledge of sharks.

Joan Barrull & Isabel Mate

**BALKAN BIODIVERSITY. PATTERN AND PROCESS IN
THE EUROPEAN HOTSPOT**

Huw I. GRIFFITHS, Boris KRYŠTUFK and Jane M. REED
(Eds.) Kluwer Academic Publishers, 2004, 357 pp.

Monografija, ki je izšla leta 2004 pri založbi Kluwer Academic Publishers, je delo 23 avtorjev, strokovnjakov iz različnih držav (Bolgarije, Češke, Grčije, Hrvaške, Nemčije, Romunije, Slovenije, Srbije in Črne gore, Ukrajine ter Velike Britanije). Večina avtorjev je sodelovala na delavnici z naslovom "Pattern and Process in Balkan Biodiversity", ki sta jo septembra 2001 v Kopru organizirala University of Hull iz Velike Britanije ter Znanstveno raziskovalno središče Univerze na Primorskem iz Slovenije ob podpori "European Science Foundation". Strokovni članki, ki so nastali kot rezultat tega srečanja, so zbrani v monografiji z naslovom "Balkan Biodiversity. Pattern and Process in the European Hotspot".

Vsebinska knjige, napisane v angleškem jeziku, je razdeljena na tri dele, ki pokrivajo tako kopne kot vodne ekosisteme in podzemni svet Balkanskega polotoka.

Žal pa izida knjige niso dočakali urednik Huw I. Griffiths, ki mu je pričujoča monografija tudi posvečena, ter David Wats in Alexei Kornishin. Delo vseh treh je pomemben prispevek k razumevanju posebnosti pokrajine in življenja na Balkanskem polotoku.

Težko bi strnila v nekaj stavkov vse izsledke dolgotrajnega dela sodelujočih avtorjev, saj je vsak prispevek v tej knjigi kot nepogrešljiv kamenček v mozaiku izjemnosti Balkanskega polotoka. Po vsem napisanem pa lahko rečem, da je ta del Evrope res nekaj posebnega tako v geološkem, geografskem, ekološkem, arheološkem, paleontološkem, predvsem pa biološkem smislu. Škoda bi se bilo sedaj ustaviti in ne nadaljevati tega, kar so nekateri že začeli.

Pattern and process in Balkan Biodiversity – an overview

Boris Kryštufek in Jane M. Reed

Avtorja v uvodnem poglavju predstavita prve opise Balkana skozi oči različnih oseb, ki Balkan prikazujejo kot divjo, negostoljubno pokrajino brez življenja. Že Ivo Andrić je z besedami velikega vizirja Jusufa Ibrahima z velikim prezirom opisal svojo rojstno deželo Bosno. Ameriški politik E. Stillman je, ne dolgo zatem, napisal: "Balkan se pričinja v Istri, na polotoku, ki se zajeda v Jadransko morje na meji z Italijo. Tu severnoitalijanska pokrajina cipres in rožnatih ter rumenih štukatur na kmečkih hišah in zelenih polj nenadoma preide v divjo karikaturu same sebe..."

Dejstvo pa je, da je Balkanski polotok dejansko središče biotske raznovrstnosti. Namen delavnice je bil vsekakor tudi poudariti velike možnosti, ki jih to območje zagotavlja za nadaljnje raziskovanje.

The physical geography of the Balkans and nomenclature of place names

Jane M. Reed, Boris Kryštufek in Warren J. Eastwood

V članku je poudarjena kompleksnost in ekstremnost geologije, topografije in podnebja Balkanskega polotoka, pokrajine, ki je izpostavljena številnim zunanjim vplivom, zaradi česar je povsem upravičena predpostavka, da je Balkan središče biotske pestrosti. Avtorji definirajo meje raziskovanega območja, pojasnijo izvor geografskih imen posameznih pokrajin, gorovij in jezer. Posebej poudarijo geološke posebnosti, topografijo in klimo, ki v veliki meri omogoča veliko biotsko pestrost Balkana.

Part 1: Terrestrial

East Mediterranean vegetation and climate change
Warren J. Eastwood

Dežele na Balkanu in v vzhodnem Sredozemlju, ki

ležijo na križišču treh kontinentalnih regij, ležijo na območju zelo raznolike klime, ki močno vpliva na razvoj flore in favne. Osnovni namen pričujočega članka je razumevanje klimatskih in okoljskih sprememb, ki so nastale v vegetaciji JV Evrope in JZ Azije. Raziskati je treba povezave in poudariti vrzeli v sodobnem razumevanju teh dveh prostranih območij. Avtor se osredotoči predvsem na spremembe holocenske in delno pre-holocenske vegetacije, pri čemer združi raziskave, ki so že bile opravljene v preteklosti, s sodobno interpretacijo stanja. V prihodnosti bo treba aplicirati še druge metode, poleg analize pelodnih zrn še analizo rastlinskih makrofosilov, nujno pa bo tudi dobro razumevanje klimatskih in okoljskih sprememb. Obstaja namreč še veliko podatkov, ki jih bomo morali vnovič oceniti, in še veliko območij, ki niso bila raziskana.

The Balkans as prime glacial refugial territory of European temperate trees

P. Chronis Tzedakis

P. C. Tzedakis, strokovnjak na področju kvartarne paleoekologije in stratigrafije v južni Evropi, se ukvarja predvsem z identifikacijo kritičnih obdobij v zemeljski zgodovini z namenom razviti ustrezne modele za preučevanje vplivov klimatskih sprememb. Glede na to, da je med poledenitvami večina severoevropske populacije gozdov zmernega klimatskega pasu izginila, je identifikacija lokacij v južni Evropi zelo pomembna. Prevladujoča je hipoteza, da naj bi ostanki te populacije preživeli v ugodnih mikroklimatskih razmerah v južni Evropi. Dolgoročno preživetje teh vrst bo omogočeno le z ustreznim zavarovanjem današnje populacije v refugialnih območjih.

Quaternary biotic interactions in Slovenia and adjacent regions: the vegetation

David Watts †

Avtor ugotavlja, da je vegetacija v Sloveniji, glede na število vrst, ena izmed najbolj pestrih na svetu (zunaj tropov). Presenetljivo pa je dejstvo, da je zelo malo znanega o njeni zgodovini (razširjenost glavnih skupin v kvartarju). V prispevku avtor oceni možne lokacije v zgodnjem holocenu, dominantne vrste ter nekatere antropogene in genetske vplive na vegetacijo.

A quantitative assessment of Balkan mammal diversity

Boris Kryštufek

Avtor poudari problem politične nestabilnosti Balkana v zadnjih dvesto letih, ki se žal zrcali tudi v sodelovanju ali bolj nesodelovanju med znanstveniki s področja naravoslovnih znanosti. Podatki o sesalcih, ki so na voljo, so zelo skopi in fragmentirani. Namen tega

članka je opis vzorca populacije sesalcev na Balkanskem polotoku, primerjava pestrosti sesalcev Balkana z drugimi regijami in ocena stopnje endemizma. V dodatku avtor podrobno predstavi raziskovalno območje, material in metode dela.

Karyotypic variation in mammals of the Balkan Peninsula

Jan Zima

Biotska raznovrstnost se kaže na treh osnovnih nivojih, in sicer na nivoju genov (sekvence baznih parov v molekuli DNK), vrst in ekosistemov. V prispevku avtor raziskuje kromosomske variacije pri sesalcih. Študije kromosomov pri tej skupini živali imajo že zelo dolgo tradicijo in zato znatno prispevajo k razumevanju njihove regionalne biotske raznovrstnosti. Večina raziskav je potekala na kromosomih malih sesalcev. Le-ti sestavljajo svojevrstno skupino organizmov, ki lahko rabijo kot model za nadaljnje raziskave. Rezultati citogenetskih raziskav lahko tako bistveno prispevajo k razumevanju endemizma določenih populacij oziroma vrst, prav tako kot smeri njihovega razširjanja v preteklosti. Študije kromosomov bodo lahko v veliki meri razrešile mnoga vprašanja glede izvora posameznih vrst.

Late Pleistocen rodent dispersal in the Balkans

Gerhard Storch

V članku se avtor osredotoči na zoogeografske relacije med pozno pleistocensko favno sesalcev z Balkanskega polotoka in še posebno na vprašanje, ali je neposredna razpršitev sesalcev med Anatolijo in Balkanskim polotokom pomembno vplivala na biotsko pestrost na Balkanu. Raziskava temelji na preučevanju drobnih sesalcev, natančneje na glodalcih iz izbranih lokalnih območij, ki izvirajo iz časov predzadnje poledenitve. Avtor ugotovi, da ni neposredne povezave med izmenjavo preučevanih sesalcev v poznem pleistocenu in njihovo sedanjo biotsko pestrostjo.

Early hominids in the Balkans

Nena Galanidou

V večini primerov avtorji omenjajo večji ali manjši vpliv človeka na biotsko raznovrstnost. Za celovit opis pojavov in razvoja prvih hominidov na Balkanu je treba združiti arheološka, paleontološka, genetska in paleoekološka dognanja. Kot prvo pa avtorica poudari, da moramo pri paleoantropoloških raziskavah najprej izbrisati današnje meje. Pleistocenski človek je bil namreč zelo mobil in zelo odvisen od ekosistemov, v katerih je živel, zato je razvijal številne strategije za preživetje. To je bilo obdobje vzponov in izumrtij številnih hominidov, živalskih in rastlinskih vrst. Za razumevanje današnjega stanja biotske raznovrstnosti je nujna pove-

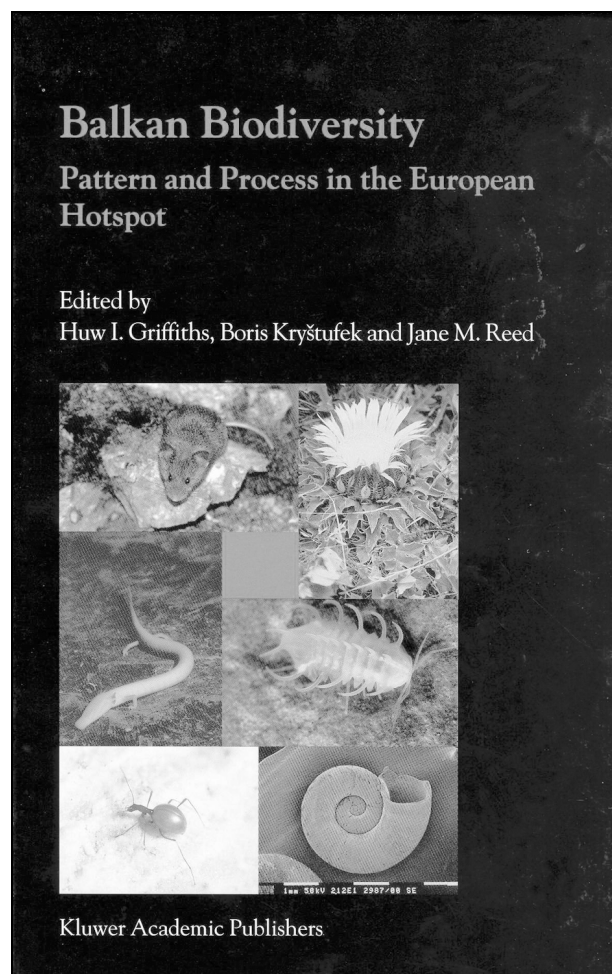
zava s tistimi, ki znajo iz drobcev razbrati zgodovino.

The biodiversity of amphibians and reptiles in the Balkan Peninsula

Georg Džukić in Miloš L. Kalezić

Raznolikost dvoživk in plazilcev Balkanskega polotoka je zelo velika. 33 vrst dvoživk (28% endemitov) in kar 71 vrst plazilcev (21% endemitov) živi predvsem v t.i. "Jadranskem trikotniku" (gorska skupina Prokletije in sosednje pokrajine), najmanj pa jih je v peripanonskem območju in Dobrudži. Za te skupine živali je Balkan središče intenzivne speciacije znotraj posameznih taksonomskih skupin. V primerjavi s plazilci in dvoživkami iz drugih delov Evrope kažejo številne specifične lastnosti. Glede na njihove omejene zmožnosti disperzije in odvisnost od temperature okolja lahko tako kopenski kot vodni plazilci in dvoživke ponazarjajo zelo občutljive indikatorje za študij biogeografskih vzorcev in procesov.

Cilj tega članka je, kot navajata avtorja, zagotoviti celoten pregled dvoživk in plazilcev Balkanskega polotoka. Članku je dodan pregled posameznih vrst dvoživk in plazilcev Balkana.



A zoogeographical review of the spiders (Araneae) of the Balkan Peninsula

Christo Deltshev

Poleg naštetega je za Balkanski polotok značilna tudi ekstremno bogata in raznolika favna nevretenčarjev. Izredno veliko je število vrst pajkov (1409) z mnogimi endemiti (379) tako na ravni rodov kot na ravni vrst. Visoki delež endemitov kaže na pomemben proces speciacije *in situ*. Ti podatki vsekakor kažejo na dejstvo, da je Balkanski polotok eden izmed pomembnejših centrov speciacije v Evropi.

Part 2: Aquatic*Distribution pattern of the aquatic fauna of the Balkan Peninsula*

Petru M. Bănărescu

Omrežje rek na Balkanskem polotoku sestavljajo reke, ki tečejo v vseh smereh. Vsaka ima svojo favništično posebnost in svoje endemite. Avtor definira sedem geografskih regij, ki se nanašajo na povodja rek, južna jadransko-jonska regija pa vključuje poleg 16 rek še številna jezera, med njimi sta Ohridsko in Prespansko jezero zaradi svojih posebnosti opisana posebej. V članku se avtor osredotoči na geološke dogodke, ki so vplivali na evolucijo Balkanskega polotoka in njegovo vodno favno.

The bivalve mollusc fauna of ancient lakes in the context of the historical biogeography of the Balkan region

Alexei V. Kornushin †

Ohridsko in Prespansko jezero sta glede favne nekaterih školjk (*Pisidium* in *Dreissena*) posebneža v primerjavi s starejšimi jezери z višjim nivojem endemizma, kot sta Bajkalsko jezero in jezero Tanganika. Vsekakor pa je za potrditev hipotez, ki se nanašajo tako na načine formacije školjk kot na izvor in evolucijo endemičnih vrst, nujno potrebna aplikacija modernih filogenetskih metod, ki vključujejo molekularno filogenijo.

A faunistic review of the modern and fossil molluscan fauna from Lake Pamvotis, Ioannina, an ancient lake in NW Greece: implications for endemism in the Balkans

Michael R. Frogley in Richard C. Preece

Avtorja ugotavljata, da je raznolikost polžev večja v fosilnih kot v sedanjih jezerih (z izjemo Ohridskega jezera). Polži z bolj eksotično oblikovanimi lupinami so tudi pogostejši v fosilnih jezerih (z izjemo Ohridskega jezera). Prav tako velja, da so polži iz podrazreda predškrgarjev značilni za fosilna jezera, medtem ko v

sedanjih jezerih prevladujejo polži pljučarji. Poraja se vprašanje, zakaj je Ohridsko jezero tako drugačno. Odgovor je verjetno v genetski analizi posameznih vrst.

Fossil ostracods, faunistics and the evolution of regional biodiversity

Huw I. Griffiths † in Michael R. Frogley

Fosilni dvoklopniki sestavljajo idealno skupino živali za razreševanje biogeografskih vprašanj. Uporaba sodobnih taksonomskih postopkov, skupaj z genetskimi tehnikami (predvsem analizo mitohondrialne DNK), nam omogoča veliko boljše razumevanje evolucije tega kompleksnega območja. Avtorja opozarjata, da je glavna ovira za pospešen razvoj paleobiogeografskih študij na Balkanu prava stratigrafska zmešnjava regionalnih depozitov fosilov. Če želimo pravilno interpretirati zbirke fosilov, bi bile potrebne sodobne podatkovne baze.

Na koncu M. R. Frogley doda, da je ta članek le senca tistega, kar je nameraval povedati H. I. Griffiths, zato sam prevzema vso odgovornost za morebitne nepravilnosti.

Tu bi opozorila le na drobno napakico na sliki 6 (str. 267), kjer je pri poimenovanju reke Krke napisano River Krk.

The potential of diatoms as biodiversity indicators in the Balkans

Jane M. Reed

Diatomeje (enocelične kremenaste alge), ki jih najdemo tako rekoč v vseh vodah v velikih količinah, so zelo raznolike in ponazarjajo zelo občutljive indikatorje trenutnih sprememb vodnega okolja. Na Balkanu je treba opraviti še veliko raziskovalnega dela tako na področju sodobnih sistematičnih raziskav kot na področju limnologije in paleolimnologije.

The current status of Adriatic fish biodiversity

Lovrenc Lipej in Jakov Dulčić

Zahodna stran Balkanskega polotoka meji na Jadransko morje, ki se prek Otrantske ožine povezuje s Sredozemskim morjem. Današnja flora in favna Jadranskega morja je posledica številnih geoloških, geografskih, klimatskih in bioloških vplivov vse od njegovega nastanka. Prvi popisi rib Jadrana segajo že v 18. st., v 19. st. pa je nastal že prvi sistematski pregled, ki pa je bil še daleč od popolnosti.

Avtorja izpostavita dejstvo, da do danes znani podatki še vedno niso popolni, strokovnjaki še vedno odkrivajo nove vrste morskih rastlin in živali, kar pripisujejo večji raziskovalni aktivnosti, boljšim tehnikam in opreми, ki omogočajo dostop do težje dostopnih habitatov in opazovanje *in vivo*. Žal pa le nekaj inštitutov na Jadranu uporablja sodobne tehnike raziskovanja morja.

Avtorja ugotavljata, da so tudi spremembe v številu vrst morske flore in favne v veliki meri posledica klimatskih sprememb in oceanografskih procesov ter nedvomno tudi velikega vpliva človeka.

Part 3: Subterranean

A census of the obligate subterranean fauna of the Balkan Peninsula

Boris Sket, Kaloust Paragamian in Peter Trontelj

Prva prava zoološka raziskovanja podzemnega sveta so se pričela šele ob koncu 18. st. oziroma na začetku 19. st. z opisom človeške ribice *Proteus anguinus* (Laurer, 1768) in drobnovratnika *Leptodirus hochenwartii* (Schmidt, 1832). Danes je seznam jamskih vrst znantno daljši, a še vedno ne končen.

V raziskavi avtorji definirajo mejo Balkanskega polotoka glede na politične meje posameznih držav, tako je izključenih nekaj predelov, kot so Romunija, Albanija, evropski del Turčije in delček italijanskega dinarskega kraka.

Diversity of Copepoda (Crustacea) in the unsaturated zone of Karstic caves of Slovenia

Anton Brancelj in Tanja Pipan

Ceponožce uvrščamo med nižje rake. Sestavljajo najštevilčnejšo skupino rakov, delimo jih na deset redov z okrog 12000 znanimi vrstami (od tega jih 250 vrst živi v evropskih jamah). Med njimi je veliko število vrst, ki živijo izključno v jamah, in tudi veliko endemitov.

Opisana študija, opravljena na območju Slovenije, ponuja možno razlago ekološke povezave jamske favne s serijo okoljskih spremenljivk in vsekakor nakazuje potrebo po nadaljnjem raziskovanju, tudi onstran meja Slovenije.

Vsi prispevki vsebujejo kratke povzetke, zahvale tistim, ki so prispevali svoje vedenje o opisani problematiki, in spisek uporabljenih virov. Podatki, ki jih avtorji navajajo v tekstu, so večinoma prikazani tudi grafično, bodisi na preglednih kartah, bodisi z ustreznimi grafi in tabelami. Knjigi je na koncu dodano stvarno kazalo. Vsekakor gre za pomemben prispevek k nadaljnjemu raziskovanju visoke biotske raznovrstnosti Balkana, saj avtorji povečini ugotavljajo, da ta pokrajina ponuja še veliko možnosti, ki jih ne gre prezreti.

Nataša Režek Donev